SEE
FOLLOWING
NOTE

VOIR
NOTE
CI-APRÈS

PARTS OF THE ORIGINAL DOCUMENT ARE OF POOR REPRODUCTIVE QUALITY.

MICROMEDIA LIMITED HAS ATTEMPTED TO PRODUCE THE BEST POSSIBLE COPY.

CERTAINES PARTIES DU DOCUMENT ORIGINAL SONT DE PIÈTRE QUALITÈ DE REPRODUCTION.

MICROMEDIA LTEE A ESSAYEE DE PROCURER LE MEILLEUR EXEMPLAIRE POSSIBLE.

ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5365

Hydraulic engineering in the fishing industry

A. V. Terent'ev, B. N. Miller and N. F. Chernigin

Original title: Gidravlicheskaya mekhanizatsiya v rybnoi promyshlennosti

In: Pishchepromizdat: 300 p, 1956
State Scientific and Technical Publishing House for the Food Industry:
300 p, 1956

Original language: Russian

Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1988

559 typescript pages

90-01468/6

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU

FOREIGN LANGUAGES DIVISION

CANADA

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS

DIVISION DES LANGUES ÉTRANGÈRES

[illegible] #2221

TRANSLATED FROM – TRADUCTION DE: Russian

INTO – EN: English

FISHERIES RESEARCH BOARD OF CANADA
LIBRARY
VANCOUVER LABORATORY
6640 N. W. MARINE DRIVE
VANCOUVER 8, B.C.

AUTHOR – AUTEUR: ① A.V. Terent'ev, B.N. Miller and N.F. Chernigin [others]

TITLE IN ENGLISH – TITRE ANGLAIS: ② Hydraulic engineering in the fishing industry] 4/

2 [Hydraul. 2 [[illegible], 4 [[illegible] — — — — , 155 [1956

544

6 [Transl. from the Russ

REFERENCE IN FOREIGN LANGUAGE (NAME OF BOOK OR PUBLICATION) IN FULL. TRANSLITERATE FOREIGN CHARACTERS.
RÉFÉRENCE EN LANGUE ÉTRANGÈRE (NOM DU LIVRE OU PUBLICATION), AU COMPLET. TRANSCRIRE EN CARACTÈRES PHONÉTIQUES.

Gidravlicheskaya mekhanizatsiya v rybnoi promyshlennosti

REFERENCE IN ENGLISH – RÉFÉRENCE EN ANGLAIS

Hydraulic engineering in the fishing industry

PUBLISHER – ÉDITEUR: Pishchepromizdat (State Scientific and Technical Publishing House for the Food Indus.)

PLACE OF PUBLICATION / LIEU DE PUBLICATION: Moscow, USSR

DATE OF PUBLICATION / DATE DE PUBLICATION		
YEAR / ANNÉE	VOLUME	ISSUE NO. / NUMÉRO
1956	–	–

PAGE NUMBERS IN ORIGINAL / NUMÉROS DES PAGES DANS L'ORIGINAL: 1 – 300

NUMBER OF TYPED PAGES / NOMBRE DE PAGES DACTYLOGRAPHIÉES: 547

REQUESTING DEPARTMENT / MINISTÈRE-CLIENT: Fisheries

BRANCH OR DIVISION / DIRECTION OU DIVISION: Inspection Service

PERSON REQUESTING / DEMANDÉ PAR: Mr. H.V. Dempsey

YOUR NUMBER / VOTRE DOSSIER No: –

DATE OF REQUEST / DATE DE LA DEMANDE: 28 July 1967

TRANSLATION BUREAU NO. / NOTRE DOSSIER No: 1297-1

TRANSLATOR (INITIALS) / TRADUCTEUR (INITIALES): WDP

DATE COMPLETED / ACHEVÉ LE: 8 July 1968

PAMPHLET FILE
No. 734

UNEDITED DRAFT TRANSLATION
Only for information
TRADUCTION NON REVISÉE
Information seulement

SOS-200-10-15 (REV. 2/66)

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU
FOREIGN LANGUAGES DIVISION

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS
DIVISION DES LANGUES ÉTRANGÈRES

CANADA

YOUR NO. VOTRE Nº	DEPARTMENT MINISTÈRE	DIVISION/BRANCH DIVISION/DIRECTION	CITY VILLE
	Fisheries	Inspection	Ottawa
OUR NO. NOTRE Nº	**LANGUAGE LANGUE**	**TRANSLATOR (INITIALS) TRADUCTEUR (INITIALES)**	**DATE**
1297-1	Russian	W.D.P./sg	8 July 1968

Gidravlicheskaya Mekhanizatsiya
v Rybnoi Promyshlennosti (Hydraulic
Engineering in the Fishing Industry),
Pishchepromizdat (State Scientific
and Technical Publishing House for
the Food Industry), Moscow, 1956.

Hydraulic Engineering in the Fishing Industry

(Second edition, revised and supplemented)

By A.V. Terent'ev, B.N. Miller and
N.F. Chernigin

Foreword

Since the appearance of the first edition of this book, hydraulic engineering has been steadily and widely introduced into the industry and has been continuously developed and improved. At the present time it represents an integral part of fish processing enterprises. Up to 2,000 fish pumps are operating on fishing vessels and at shore installations, while the overall length of the various fish conduits amounts to 100,000 linear metres. /3/[*]

---

[*] Numbers in the right margin indicate the corresponding pages in the original.

Over the past years scientific research has been carried out on improving the design of existing fish pumps and on creating new types of such pumps, on the establishment of a method of planning long fish pressure conduits and on the creation of new auxiliary devices at fish pumping establishments, as well as on the improvement of such auxiliary devices that are already in use. A wide circle of engineering and technical workers and industrial innovators, who have submitted a number of valuable suggestions, many of which have been introduced into the industry, has taken part in the work involved in the further introduction and improving of hydraulic engineering equipment.

All of this taken together has brought about the necessity of systematizing the new, extensive material relating to hydraulic engineering at fishing industry enterprises, in order that all engineers, technicians and leading specialists of the industry may utilize such material in their daily practical activity.

All of the material in the first edition of this book has been considerably supplemented and revised.

Contents

page

Foreword.. 1

Chapter I. GENERAL INFORMATION ON HYDRAULIC ENGINEERING IN THE FISHING INDUSTRY.......... 3

1. The Value of Hydraulic Engineering in the Fishing Industry...................... 3
2. An Outline of the Development of Hydraulic Engineering in the Fishing Industry............................. 7

Chapter II. SPECIAL FEATURES OF THE APPLICATION OF HYDRAULIC ENGINEERING AT ENTERPRISES OF THE FISHING INDUSTRY........................... 34

1. General Conditions for the Application of Hydraulic Engineering at Fishing Industry Enterprises.................. 34
2. Fish Firmness.......................... 45
3. Physical Characteristics of Some Fish..... 55
4. Auxiliary Materials and Waste Products in Hydraulic Engineering Systems at Fishing Enterprises....................... 63

Chapter III. WATER-JET FISH PUMPS......................... 70

1. The Operating Principle of a Water-Jet Pump.............................. 70

page

2. The Design and Operation of the NCh-3 Water-Jet Fish Pump.................... 73
3. The NCh-3 Fish-Pumping Unit.............. 75
4. Calculating the Efficiency of an NCh-3 Fish-Pumping Installation.............. 78
5. Rating a Water-Jet Fish Pump............. 80
6. Experimental Research.................... 97
7. Installation and Operation of a Water-Jet Fish Pump................................ 100
8. The EKR-1 Water-Jet Fish Pump with Annular Delivery of Operating Water.... 123
9. A Portable Water-Jet Fish Pump Designed by B.T. Burkal'tsev.................... 128

Chapter IV. CENTRIFUGAL FISH PUMPS...................... 133
1. Operating Principle and Purpose of Individual Parts.......................... 133
2. The Basic Operating Parameters of a Centrifugal Fish Pump and Brief Data from the Theory of Fish Pumps.......... 138
3. The Operating Characteristics of Centrifugal Fish Pumps................. 148
4. The Theory of the Operating Process of a Centrifugal Fish Pump.................. 156

page

5. Centrifugal Fish Pump Designs............ 166
6. Improving Fish Pump Design............... 185
7. Centrifugal Fish Pump Drives............. 202
8. The Operation of Centrifugal Fish Pumps.. 209

Chapter V. MULTISTAGE FISH-PUMPING UNITS............... 217
1. The Concept of the Multistage Pumping of Fish through Pipes..................... 217
2. Centrifugal-Action Multistage Fish Pumps. 225
3. Two-Stage Ejection and Composite-Action Fish-Pumping Units..................... 233
4. Prospects for Developing Designs of Multistage Fish Pumps.................. 249

Chapter VI. HYDROPNEUMATIC FISH-PUMPING UNITS........... 253
1. The KRCh-1 Fish-Pumping Unit............ 253
2. Calculations for the Basic Elements of the KRCh-1 Unit........................ 268
3. A Hydropneumatic Fish-Pumping Unit....... 282

Chapter VII. FISH CONDUITS.............................. 288
1. General Information...................... 288
2. Fish Intake and Delivery Conduits........ 289
3. Hydraulic Trough Conveyers............... 315

page

Chapter VIII. AUXILIARY DEVICES FOR FISH-PUMPING UNITS.................................. 326

1. Priming Devices and Return Valves........ 326
2. Auxiliary Pumps.............................. 352
3. Diffusers.................................... 360
4. Water Separators............................. 363

Chapter IX. HYDRAULIC ENGINEERING IN THE CATCHING OF FISH.................................. 379

1. General Remarks.............................. 379
2. Unloading Fish from a Drag Seine with a Fish Pump.................................. 382
3. Unloading Fish with a Fish Pump from the Hearts of Trap Nets into a Kungas and from a Kungas onto the Shore............ 383
4. A Floating Fish-Pump Unit for Work on Rivers.................................. 385
5. Unloading Herring from the Heart of a Trap Net Using a Net Corridor and a Fish Pump.................................. 388
6. The Use of Centrifugal Fish Pumps for Unloading Fish from Drag Seines in Dagestan.................................. 390

page

7. The Use of Centrifugal Fish-Pumping Units for Unloading Fish from Purse Seines, Trap Nets and Alamans on the Sea of Azov.............................. 395
8. Experiments in the Electric Catching of Fish Using a Fish Pump................. 402
9. Catching Fish with an Electric Light and a Fish-Pumping Unit................... 419
10. Net Frames................................ 426
11. The Use of Pumps for Placing Trap Nets in the Northern Caspian.................. 433

Chapter X. HYDRAULIC MECHANIZATION IN THE PROCESSING OF FISH............................. 434
1. The Fundamentals of Applying Hydraulic Mechanization to the Processing of Fish 434
2. Hydraulic Mechanization in the Thermal Processing of Fish...................... 436
3. The Hydraulic Mechanization of Fish-Grading Operations....................... 446
4. The Hydraulic Mechanization of the Pickling of Fish......................... 451
5. The Speed of Salting....................... 485
6. Basic Systems of Pickling Fish in Circulating Brine....................... 488

page

Chapter XI. A LINE FOR THE MULTIPLE HYDRAULIC MECHANIZATION OF FISH-PROCESSING ENTERPRISES.............................. 510

1. A Mobile Line for the Pickling of Small Fish in which the Raw Fish are Unloaded by Fish Pump and Conveyed through Pipes 510
2. A Prospective Scheme for the Multiple Hydraulic Mechanization of the High-Speed Barrel Pickling of Small Fish, Using Circulating Brime and without a Period of Settling for the Barrels..... 519
3. Multiple Mechanization of a Herring Plant where Fish are Pickled in Circulating Brine and Packed in Barrels............ 523
4. Prospective System for a Consolidated Herring Pickling Plant with Hydraulic Mechanization of Receiving and Processing.............................. 534
5. A Prospective System for the Multiple Hydraulic Mechanization of the Pickling of Pink Salmon......................... 535
6. The Multiple Mechanization of the Catching and Processing of Sprat on Board Ship............................... 540

Chapter I

GENERAL INFORMATION ON HYDRAULIC ENGINEERING IN THE FISHING INDUSTRY

1. The Value of Hydraulic Engineering in the Fishing Industry

In the fisheries of prerevolutionary Russia all 15 operations, including the heaviest and most laborious, were carried out exclusively by hand.

It was only after the Great October Revolution, when a socialist fishing industry began to be created, that the question was raised, with all acuteness, of the need to carry out extensive measures for rationalizing and mechanizing such industrial processes as, for example, casting and hauling seines, unloading fish from seines and transport ships, and conveying fish around processing plants, as well as for streamlining and mechanizing various operations involved in the processing, catching, etc., of fish. A number of peculiarities inherent in the fishing industry make it an especially urgent problem to realize the mechanization of these processes.

The first peculiarity is a sharp seasonal fluctuation in the catching of fish, where the State fishing plan must be fulfilled over a comparatively short period (determined mainly by the conditions under which the fish migrate).

A second peculiarity consists in a sharp irregularity in the fish catch in the course of the fishing season (peak periods); this irregularity depends mainly upon a number of natural factors.

A third peculiarity is the extent to which the quality of fish products depends upon the rapidity and efficiency with which the fish that are caught are delivered, unloaded and processed.

The fourth peculiarity includes a number of special sanitary requirements made of fish as a food product.

Where in the fisheries of prerevolutionary Russia these peculiarities appeared insurmountable and man had to submit to them, now, with the powerful development of our socialist science and technology, we have from year to year learned how to overcome them to an ever greater extent and to subordinate them to our requirements. One of the main factors promoting the development of a socialist fishing industry is the extensive carrying out of measures for the mechanization of heavy and laborious operations.

Within the fishing industry, aside from the mechanization /6 of laborious processes involved in the catching, unloading and processing of fish, there are also numerous auxiliary operations which are to be mechanized; these operations are related to the movement of such materials as salt, packaging, tin plate, lumber, nets, fishing gear, various kinds of fuel, etc., which are widely used in the fishing industry.

In the development and introduction of mechanization at fishing industry enterprises we have had both to create original and specific installations and to utilize the experience of other branches of industry.

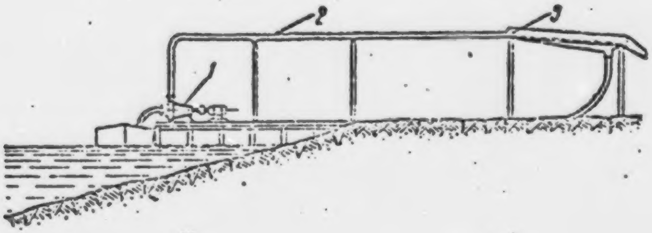


Figure 1 - Diagram of hydraulic mechanization at fishing industry enterprises:

1 - fish pump; 2 - fish pressure conduit; 3 - water separator.

Thus in the fishing industry cranes of various designs with diverse gripping devices, elevators and other machinery are used where the operations of transferring fish and other cargoes are being mechanized. Conveyors, narrow-gauge tracks, motor transport, elevators and motorized carts, etc., are widely used for conveying fish and other freight.

During the last 15 to 20 years, together with the devices and equipment for the mechanization of various heavy and laborious operations, the hydraulic method of mechanization has begun to be applied; with every year it has spread ever more widely in the enterprises of the fishing industry.

The essence of the hydraulic mechanization method consists in the transfer of fish in a liquid agent during unloading and conveying: fresh fish is moved in water, and salted fish, in brine. The use of basically only one mechanism - a fish pump of one design or another - for unloading and conveying operations makes this method simple and convenient.

At the present time, devices for hydraulic mechanization at fishing industry enterprises are usually made according to the following scheme: a fish pump with an intake hose and auxiliary devices, fish conduits of the pressure or chute type, and water separators (see Fig. 1).

Many years had to be spent in persistent work, and /7 numerous research and experimental studies carried out, before the idea of using hydraulic engineering in the fishing industry won due acknowledgement and got on a firm path to further development. This system is now basic where the processes of unloading and conveying fish are being mechanized.

Hydraulic engineering devices are simple and convenient to use. Moreover, hydraulic engineering accelerates the unloading of fish from fishing gear, which promotes the better operation of the latter. The unloading at fish plant moorages of fish from the holds of fishing and transport vessels is considerably speeded up; hence the time spent by such vessels in idle standing while being unloaded is reduced, and the turnaround time of the fishing fleet is increased. There is a significant decrease in the number of workers occupied in unloading and conveying fish; their work is facilitated, since heavy physical labour is replaced by the lighter work of controlling the fish pump installations and supervising the operation of the auxiliary devices, the fish conduits and the water separators.

Thus the application of hydraulic engineering at fishing industry enterprises promotes an increase in output per man-hour.

2. An Outline of the Development of Hydraulic Engineering in the Fishing Industry

The first hydraulic engineering devices employed in the fishing industry were open pan troughs, which were used at Kamchatka canneries for conveying raw fish from receiving wharves in a stream of water.

The troughs were installed sloping in the direction of movement of the fish and were termed hydraulic conveyors. As far back as the end of the nineteenth century similar troughs were used in the beet sugar industry for conveying beets in water for considerable distances. It may therefore be considered that conveyors were brought from the beet sugar industry to the fishing industry.

At first, however, fish were fed into the troughs of the hydraulic conveyors with the aid of mechanical lifting devices mostly of the inclined scraper conveyor type, which are even now used in Kamchatka.

From 1925 to 1926 for the first time in the USSR there occurred the idea of the possible use of pumps for unloading fish from fishing gear and ships. At that time it was considered that the types of pumps could be used in which the fish would not pass through revolving parts which could damage it. It was therefore initially proposed to use an emulsion pump (an air lift). This pump was a stationary installation which was successfully /8 used in the beet sugar industry, in oil fields, and, in certain special cases, in water supply and sewage.

The operating principle of the air lift was based on the difference in the specific gravity of the columns of water in the intake and pressure elbows of a syphon located below the surface of the water. Compressed air was fed by a compressor into the lower part of the pressure elbow; as a result, the specific gravity of the liquid in it was reduced, and a flow of water was established from the intake elbow towards the pressure elbow.

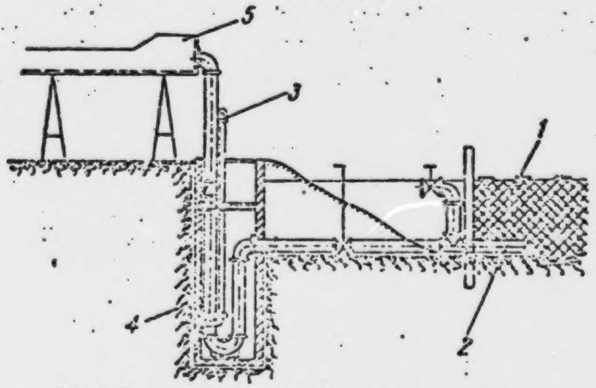


Figure 2 - Diagram of installation of an emulsion pump (air lift) for unloading fish from a seine:

1 - seine bag; 2 - intake pipe; 3 - air feed pipe; 4 - lifting pipe; 5 - chute conveyor.

From 1926 to 1928 in the Astrakhan region, in Azerbaidzhan and at Vladivostok experiments were carried out on using air lifts for unloading fish from drag seines. The complexity and awkwardness of the whole device (see Fig. 2), however, the necessity for powerful compressor and power installations, a comparatively limited fish discharge (because of the low content of the latter in the water that was pumped over), and the low height to which the fish were conveyed, resulted in no further progress beyond these experiments.

In 1949 at the Murmansk Fishing Combine A. Yu. Khranovskii renewed experiments on using an emulsion fish pump for unloading salted herring from vats. Here use was made of a compressor installation which was in operation at the Combine and from which compressed air was fed to the emulsion fish pump. The latter had been made in the form of a portable structure which was inserted into the tank containing the herring. The transfer, by pumping, of salted Murmansk herring with an emulsion fish pump proved quite feasible and gave good results. A. Yu. Khranovskii's experience, however, has not yet been introduced into the industry.

In 1935 Chief Engineer N.F. Chernigin proposed a water-jet pump, or hydraulic elevator, whose operation was based on the principle of ejection, for unloading fish. In 1936 in the Astrakhan region, after comprehensive theoretical and constructive development under the scientific direction of Professor P.A. Sviderskii, numerous tests were carried out on this pump, which was subsequently introduced into the industry. /9

Later, N.F. Chernigin developed several variants of industrial installations using a water-jet pump for transferring live fish from a drag seine to a live fish carrier, unloading live fish from the carrier to the fish receiving area, and unloading fresh salted and lightly salted fish from a ship's hold onto the fish receiving area or onto a conveyor. The industrial installation of a water-jet pump combined with auxiliary attachments for unloading fish is termed an NCh-3 fish pump (see Fig. 3).

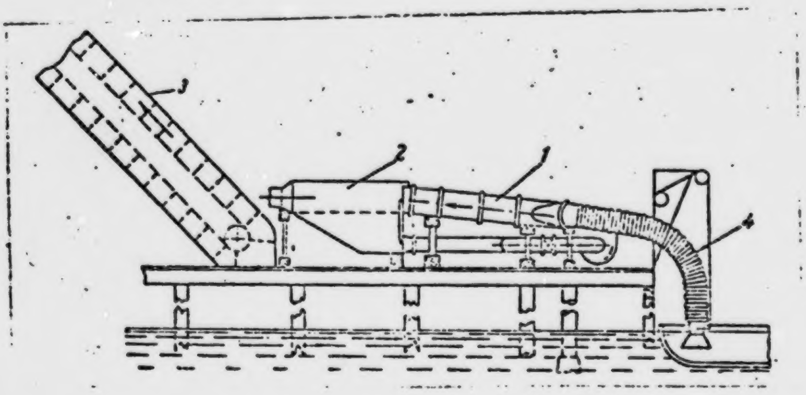


Figure 3 - Diagram of the installation of a water-jet fish pump:

1 - fish pump; 2 - water separator; 3 - elevator; 4 - fish pump intake hose.

These fish pumps were initially used in the Volga-Caspian Basin. From 1942 onwards they began to be employed in Kamchatka and in other regions of the Far Eastern Basin.

The water-jet fish pump was subsequently improved by the creation of a closed diffuser. This made it possible to increase the pressure in the delivery conduit.

Moreover, a closed diffuser made it possible to apply the system of coupled fish pumps, i.e., those that were connected in sequence one behind the other. This latter arrangement solved the problem of the mechanized unloading of fish across a surf zone in Kamchatka. The experiments of N.F. Chernigin in 1948 confirmed the possibility of pumping fish for a distance of more than 1,000 metres, which opened extensive prospects for the further introduction of hydraulic engineering.

The water-jet fish pump was the first really effective fish pumping installation at fishing industry enterprises in the USSR. By means of such fish pumps, fresh fish was unloaded /10 without any damage whatever to the fish itself and at a fairly rapid rate. Inherent in this type of fish pump, however, were certain deficiencies, the most fundamental of which were the negligible height to which the fish was raised (three metres for salmon and run-of-the-mill species, and 2.5 metres for herring), low efficiency and the awkwardness of the whole installation.

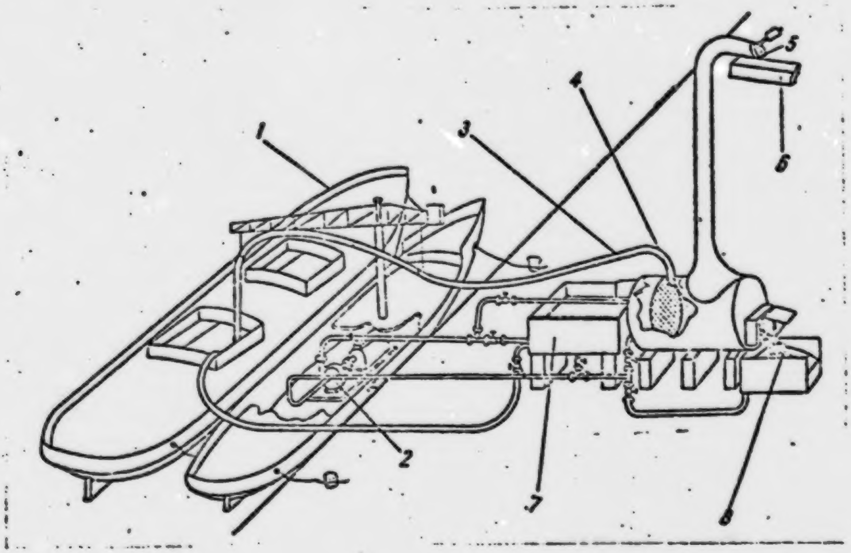


Figure 4 - Diagram of the assembly of a chambered fish pump:

1 - ship being unloaded; 2 - centrifugal pump;
3 - intake hose; 4 - chamber; 5 - valve; 6 - hydraulic conveyer; 7 - brine tank; 8 - discharge of used brine.

In 1938 I.V. Borshchenko and A.E. Nitochkin proposed the use of a pump whose operation was based on the utilization of a vacuum created in a hermetic chamber by pumping water from the latter in order to draw fish into the same chamber.

In 1938 I.V. Borshchenko used this type of fish pump installation in the Kerch region for unloading anchovies, and in

1940 and 1941 tests were carried out at Astrakhan on the use of an installation of this kind for unloading run-of-the-mill fish (including lightly salted fish). This installation was designed by V.D. Borodin, I.V. Borshchenko and A.E. Nitochkin and was termed a chambered fish pump.

A hermetic reservoir (chamber) formed the main part of the installation. An intake hose with a reverse valve at its end was attached to the chamber on one side, and a metal pipe for unloading fish, on the other (see Fig. 4). The chamber was connected to a centrifugal pump, which could be used for pumping water or brine into or out of the chamber. Before the beginning of work the chamber and the intake hose were filled / 11 with water by means of the centrifugal pump. The water was then pumped out with this same pump. Owing to the hermetic state of the chamber, a vacuum was created in it. A ship's hold containing fish was first flooded with brine (since the operations basically involved lightly salted fish), a rubber intake hose was lowered into the brine, and under the effect of atmospheric pressure the fish and brine filled the chamber. After the chamber was filled and the operation of the pump discontinued, the air cock was opened and the pressure in the chamber became equal to the atmospheric pressure. Brine was subsequently pumped into the chamber.

Owing to its lower specific gravity, the fish in the chamber floated up and was fed together with the brine through the discharge pipe towards the processing area.

The main performance figures, obtained when a chambered fish pump was tested at Astrakhan, were as follows: delivery, 30 tons per hour; full lift, 15 metres; required power, 11 kilowatts; residual pressure in the chamber, 40% (of atmospheric pressure).

In spite of certain merits, the first of which should be considered the possibility of unloading lightly salted fish (of loose consistency) without marked damage, the chambered fish pump received no practical application. This could be explained by the awkwardness and complexity of the entire installation, difficult maintenance, and mainly by the fact that the chamber was not completely emptied of transshipped fish.

From 1938 onwards, some specialists of the fishing industry, in spite of the prejudice that had existed against using pumps with revolving parts for transshipping fish, proceeded to test and improve various existing types of centrifugal pumps, adapting them for unloading fish.

Interest in using centrifugal pumps for unloading fish resulted from the compactness and simplicity of the installation, its ease of maintenance, considerable pressure head and high output. Single-stage cantilever centrifugal pumps of the sewage type were used for transshipping fish.

These pumps had only two blades on the operating wheel, wide internal passages and one-way suction, which created the most favourable conditions for pumping fish without damaging it.

In the Kerch region in 1938 and 1939 A.V. Terent'ev and others tested pumps of this kind on fish of various species and sizes. At first, the pumps damaged considerably the fish that they transferred, but subsequently, as a result of improvement of the pumps themselves and of associated operating procedures, the damage to fish ceased.

In 1939 A.E. Nitochkin and L.S. Oganesyan assembled the /12
first experimental mechanized installation for pickling anchovies in barrels. This installation was designed by B.N. Miller in consultation with N.T. Berezin's technological department at Kerch. Two 4NF sewage-type centrifugal pumps were used as a discharging device, while a hydraulic trough conveyor differing somewhat in design from those employed in Kamchatka was used as a conveying device. After work with these pumps yielded positive results, owing to detailed tests and refinements, the mechanized installation was put into industrial operation. This was the first

industrial unit in which centrifugal pumps were successfully used for unloading fish, and a complex scheme for the pickling of anchovies in barrels was fully realized.

In 1940 A.V. Terent'ev, jointly with T.M. Badirov and others, used an 8NF pump unit on a tractor for unloading herring from drag seines at a Dagestan fish plant and thereby created the first mobile fish pumping installation.

Also in 1940, at the suggestion of B.N. Miller, a 4NF pump unit was mounted and tested by B.I. Raevskii and M.N. Saltykov on a ship in Kerch Strait for unloading fish directly from fishing gear.

The successful operation of the above units considerably widened the field of application of centrifugal fish pumps, since mobile units began to be applied in addition to stationary equipment.

In 1941 A.V. Terent'ev improved a fish pumping unit in Dagestan and put it into operation. At the same time, Terent'ev proposed to convey fish in pipes under pressure. Thorough tests of this method gave positive results, and it was also introduced into the industry.

Apart from work on the above units, tests of centrifugal pumps of the sewage type for unloading fish were additionally conducted in certain basin areas, including Murmansk, (for unloading herring from blocking seines) and in the Far East (for unloading sardines).

In spite of a certain improvement in the design of pumps of the sewage type, and a refinement of the systems under which they operated, as a result of which mechanical damage to transshipped fish was reduced to a minimum, pumps of the sewage type nonetheless did not fully satisfy the demands made of centrifugal fish pumps.

In 1946, on the basis of his study of experience in the use of sewage pumps for unloading fish, and his investigation of their constructional features, B.N. Miller proposed to develop a design for special centrifugal fish pumps. Using his preliminary calculations, the Design Department of the State Institute for the Design of Fishing Industry Enterprises and Machinery (Giproryba)designed pumps of three type sizes (the NR-100, the NR-150 and the NR-200). These fish pumps ensured that fish could be transshipped without being damaged. Tests carried out on fish pumps of the NR type and experience in the use of this equipment demonstrated its good operational qualities, while the organization of the manufacture of such pumps at a series of machine shops in the fishing industry ensured the further broad development of hydraulic engineering in this industry. /13

In 1949 the Khabarovsk Machine Shop of the Chief Eastern Directorate of Packaging of the Ministry of the Fishing Industry of the USSR (Glavvostokrybtara) designed, built and tested a centrifugal fish pump of the NR type with an intake branch pipe diameter of 250 mm (the NR-250) (the designers were Vaikhanskii, Kukushkin, Samylov, and others); this pump was subsequently improved by Giproryba. The pump was successfully tested at enterprises of the Chief Directorate of the Fishing Industry in Kamchatka (Glavkamchatrybprom) and the Chief Directorate of the Fishing Industry in the Amur Basin (Glavamurrybprom) for pumping large fish (of the salmon family), and was used for unloading salmon from kungasy[x] and net bags and for conveying fish to the shore across a surf zone. It has thus become possible to use centrifugal pumps for conveying almost all species of commercial fish caught in the waters of the Soviet Union.

In 1950 fish pumps of type NR were standardized and were redesignated the RB-100, the RB-150, the RB-200 and the RB-250, as they have been termed up to the present.

---

[x] Translator's note: the kungas is a type of Soviet Far Eastern sailing vessel for which no suitable English equivalent is available. It is used for net fishing; it is 12.6 m long, 2.5 m wide, and has a draft of 0.5 m. The cargo capacity of the kungas is 5 tons.

Centrifugalfish pumping installations [of this type] are very simple. The fish pump itself is operated by an electric motor or other engine. A flexible clutch can be used for the transmission, as can a belt, chain or other form of flexible drive. The fish pump can be primed from a water pipeline or from a priming tank. In this case, a return valve is installed on the end of the intake hose.

If priming is accomplished by drawing off the air from the intake hose and the pump housing with a suction pump, a return valve is installed on the delivery branch pipe of the fish pump. The fish that is unloaded is discharged either into a hydraulic conveyor trough or into a pipeline under pressure. Owing to the considerable pressure developed by the centrifugal pump, it serves simultaneously as an unloading and conveying device.

In 1949 V.V. Kozyrev and I.V. Borshchenko, and then in 1950 B.T. Burkal'tsev and Engineer Zadorozhnyi, developed special fish pump intake nozzles for pumping fresh fish out of small fishing vessels either without water or with a low water content in the working mixture. These nozzles were used in the Azov-Black Sea and Baltic Basins for pumping out fresh anchovy, tiulka, and Baltic herring from small fishing vessels, and for pumping out salted fish from pickling tubs.

By 1950 the use of hydraulic engineering in the extractive fishing industry had considerably expanded. The State Institute for the Planning and Design of Fishing Industry Enterprises and Machinery (Giprorybprom) had designed fish pump units in sets with engines mounted on a single frame. /14 These units were designated RBU and were equipped with internal combustion engines for use in areas lacking electric power. Fish pump units of the RBU type began to be produced in series by machine shops of the Ministry of Fisheries of the USSR, and were widely used, particularly in the fishing enterprises of the Far East, where the RBU-200 and RBU-250 units were installed on fishing kungasy, and the fish that was caught (herring and fish of the salmon family) was unloaded with these units from floating net bags or directly from fishing gear and was conveyed through pipelines under pressure to processing areas.

In the Azov-Black Sea Basin the number of fish pump units on motor vessels for directly unloading fish from fishing gear increased considerably. At the same time, power was supplied to the fish pumps from marine engines.

After underwater electric illumination for catching sprat (introduced in the Caspian Basin by a group of fishing industry workers under the direction of Professor P.G. Borisov) became widely used, the All-Union Scientific Research Institute of Ocean Fisheries and Oceanography (VNIRO)(I.V. Nikanorov and others) developed and successfully applied a technique whereby accumulations of sprat attracted by underwater illumination were caught directly with a fish pump whose intake hose was lowered to the required depth. Further hydraulic mechanization of the chilling of sprat on board ship, together with the packing of this fish into boxes secured the creation of a complex mechanized system of catching and processing southern (Caspian) sprat at sea.

Aside from the use of underwater illumination, application was also made of the effect on fish of an electrical field. Experiments carried out under industrial conditions by the Pacific Scientific Research Institute of Ocean Fisheries and Oceanography (TINRO) (N.F. Chernigin) in Kamchatka with the use of direct and alternating current together with fish pumping units acting as catching and unloading devices, yielded encouraging results. These experiments must be continued in order to obtain industrial units.

In 1951 and 1952 the Mechanization Laboratory of VNIRO (B.N. Miller and others) conducted a series of investigations in order to establish the best systems for the operation of centrifugal fish pumps and to improve them further.

At the same time, studies were made of the further introduction and improvement of a system of conveying a mixture of fish and water through pipelines under pressure for long distances. Those studies were conducted at VNIRO (by I.I. Teslin and others) and at TINRO (by N.F. Chernigin) as well as at a number of fishing industry enterprises (by N.N. Chirkov, D.D. Shed'ko and others). For this purpose, coupled units of two centrifugal fish pumps or one water-jet and one centrifugal fish pump were used. In Kamchatka at the present time mixtures of fish and water are conveyed through pipelines under pressure for distances in excess of one kilometre. /15

It was for this purpose that a pneumatic fish pump unit, with which a mixture of fish and water was raised to a height of 45 metres, was developed and tested under industrial conditions in the VNIRO Mechanization Laboratory (I.I. Teslin).

Besides improving types of centrifugal and water-jet fish pumps in operation, TINRO (N.F. Chernigin) designed and tested in Kamchatka a new type of fish pump which represented a combination of a sluice gate connected to a vacuum pump, with a pipe system operating on the principle of an air lift. This type of fish pump, which has been designated the KRCh, has still not reached the required performance standards in industrial tests; it is continuing to be improved.

The large quantities of water arriving together with fish at areas where the latter is processed, when mixtures are pumped by fish pumping units, have necessitated the creation of special devices for separating this water. For this purpose, use is made of perforated pipes and troughs, reticulate conveyors, vibrating perforated troughs and cascade water separators of various designs (the Topchienko-Sakharnov, the Petrenko, and types of equipment produced by the State Institute for the Design of Fishing Industry Enterprises and Machinery (Giprorybprom) and by the Directorate for Special Installation and Construction in the Fishing Industry (Spetsmontazhrybstroi). On certain of the most highly developed types of such equipment, up to 95% of the water is separated.

Outside the Soviet Union, as early as the 1920's attempts were also made to use pumps for transferring fish. Foreign designers, however, did not realize that the main feature of a fish pump that distinguishes it from other pumps is the capacity for transferring fish without damaging it.

In the USA the first proposal to transfer fish by pumping was made by Rubach and Holigen in 1922 and again in 1926. They proposed an utterly fantastic project for equipping a fishing vessel with a water-jet pump which would run through the entire ship from the pump itself below the waterline to the deck at the stern. The opening of the intake pipe was to be equipped with side nets similar to a trawl. This, then, was a proposal for fishing gear and not for a means of mechanizing transshipment operations.

Describing this proposal in 1931, K.A. Smetanin indicated that it was never realized. If we examine the pump proposed by Rubach and Holigen, we can show quite precisely the reasons why the American proposal could not be realized and remained an imaginary "project". We are able to demonstrate these reasons on the basis of (a) more than 20 years' experience in operating fish pumps in the USSR, and (b) the theory that we have developed of the intactness of fish when it is transferred with pumps. The fact is that Rubach and Holigen used for their ship not a fish pump, but rather a suction dredge, and made in it none of the changes required by the specifics of operations with fish, and, when they left both the pipe for supplying fluid and the nozzle in the path of movement of the fish that was to be drawn in, they created all of the conditions for the inevitable damage of all fish in the pump. /16

A second American device for pumping fish was a centrifugal pump produced by the Well Works Company with an intake pipe diameter of six inches and a single-bladed wheel moving at 900 rpm. This pump was in operation at the Hovden Sardine Plant in California in 1929. In describing this pump, G.A. Kryshov indicated that it was the only pump in the USA that was used for transferring fish, and that it caused so much mechanical damage to the fish that it could be used only for transferring sardines to a recovery plant. This, then, was not a fish pump. The Fishing Gazette reported on the same pump in 1940 as being unique.

All recent patents for fish pumps have been issued long after 1940. Thus Channel patented a water-jet fish pump in 1947, and a centrifugal fish pump was patented by the Yeomans Company in 1945 and by Allen, Sherman, Hoff and Company in 1946. D. Taft patented a centrifugal fish pump in 1946. All of these fish pumps began to be built in 1947 and to be operated no earlier than 1948.

In the USA in 1947 Channel proposed a water-jet fish pump named "Peri-Jet". According to a report in the Fishing Gazette, this pump represented a water-jet apparatus with a circular water feed line, and in tests demonstrated a fish delivery of 30 to 40 tons per hour. In reporting on this, the Fishing Gazette indicated that the use of a pump for transferring fish in water directly from the hold of a fishing vessel was a technical novelty which had never been applied previously. Moreover, the "Peri-Jet" pump, as indicated in this report, in contrast to other fish pumps in which the fish passed through revolving blades, caused no mechanical damage to the fish during the tests. This report of the Fishing Gazette confirms that the concept of the fish pump as a pump transferring fish without damaging them appeared in the USA about 1947. Another part of this report confirms that in the USA up to 1947 it was not known how to transfer fish by means of centrifugal pumps without damage, i.e., there were no fish pumps in the correct sense of this term.

All of the [fish] pumping units that have been in operation up to the present time in USA fish plants have been used for pumping raw material for the recovery of by-products, and not for transferring fish that is to be used for food; they therefore cannot be considered to be fish pumps.

In Japan in 1934 two centrifugal pumps manufactured by the M. Fudzita Company were installed and used for transferring herring. According to reports in the Japanese fishing industry press of that time, these fish pumps transferred herring to be pickled for food at fish plants, i.e., they were real fish pumps. The pumps had the following specifications:

diameter of intake pipe - 8";
operation - a 40-h.p. marine engine; /17
installation - on a fishing launch;
fish delivery - 270 tons per day.

The use of centrifugal fish pumps for unloading and conveying fish considerably increased the rate at which fish arrived for processing. The necessity arose of mechanizing fish processing in a way which would ensure the synchronous and multiple carrying out of all stages in the flow.

Of special interest for solving the problems of the all-round mechanization of the most laborious operations with the aid of hydraulic methods is the pickling of fish in circulating brines. The development of such methods of pickling began independently of the development of notions of all-round mechanization.

The first to be tested was T.M. Borisov's suggestion of pickling fish in circulating brines. This proposal consisted in pouring the fish being salted together with a stream of brine through vats arranged in steps, from the topmost to the bottom. The tests, however, yielded negative results, since the bulk of the fish being salted did not pass from tub to tub owing to the fact that under the influence of the cohesive force between individual fish there formed a solid mass which it proved impossible to break up and direct to the overflow either with the force of an undirected flow of brine, or by moving the mass of fish forward by hand without breaking it up.

Moreover, the use of the system of pickling fish in circulating brine according to the method of T.M. Borisov required the construction of new brine sheds with an extremely heavy make of stepped pickling vats. Another, no less serious, shortcoming was the flow structure, in which only one-fifth of the pickling capacity (with five stages of tubs) could be loaded with fish simultaneously, whereas the seasonal fluctuations of commercial fishing and the presence of sharp peaks in the catch not infrequently require the maximum simultaneous utilization of pickling capacity.

The next proposal with regard to pickling fish in circulating brine was that of N.T. Berezin, in which the fish was to be pickled in ordinary vats equipped with piping and troughs for supplying and discharging the brine. Designs based on this proposal were prepared by the State Institute of Planning for the Fishing Industry (Giproryba) (S.I. Gakichko, V.D. Borodin, A.V. Terent'ev and others).

N.T. Berezin's method of pickling fish in circulating brine was tested for several years under various conditions. Shad was salted by this method in Dagestan, as were Caspian herring at Astrakhan and sardines and herring in the Far East. The results that were obtained showed that this method was practical and that it gave fully satisfactory results in the pickling of medium-sized fish.

A more serious and difficult problem was that of / 18 pickling small fish in circulating brine, since the capacity of such fish for rapidly adhering into a compact mass impenetrable to brine is much greater than among larger fish, for example, herring.

From 1948 to 1949 A.A. Timofeev at the Azov and Black Sea Fishing Trust (Azchergosrybtrest) and E.G. Vechkanov at enterprises of the Ministry of the Fishing Industry in the Ukrainian SSR developed and assembled industrial units for mechanizing the continuous pickling of small fish (tiulka) in circulating brines. The units represented long tanks (baths) with forced movement of fish. In spite of the fact that quite good results were obtained in operations with these units, they received no further application because of their awkwardness and relative complexity.

In 1948 A.S. Zakharov proposed to pickle herring in circulating brine through which the fish would be moved in containers with the aid of a winch. Because of structural difficulties, however, the unit, which was built for pickling of this type on Sakhalin, was not used.

Hydraulic engineering has been widely applied in the processing of herring on Sakhalin. Since the quantity of herring arriving for processing has considerably increased owing to the use of fish pumping installations, previously employed methods of pickling herring with dry salt have ceased to satisfy the required output, and brine pickling, i.e., the pickling of fish in saturated aqueous salt solutions, has begun to be employed. The extremely laborious work of unloading pickled herring from vats has been successfully mechanized by Yu. S. Pokrovskii, whose method, based on the principles of hydraulic engineering, has been widely used at the fishing enterprises of Southern Sakhalin (for more details on this subject, see Chapter X).

Aside from Yu.S. Pokrovskii's method, in recent years mobile centrifugal fish pump units of type RB, and water-jet fish pumps, have begun to be used for unloading vats containing pickled fish.

At the present time, a scheme for all-around mechanization with a high output has been developed and realized at several herring plants in Southern Sakhalin. The herring is unloaded from fishing gear, kungasy or net bags at the wharves of the fish plants with an RBU-200 fish pumping unit; the herring is pickled in vats using circulating brine according to N.T. Berezin's method; mobile pump units are employed for unloading pickled fish, and the fish is conveyed within the pickling plant through troughs and pipes in a stream of brine.

At the Murmansk Fish Combine an experiment was set up on grading fish according to their degree of saltiness by utilizing the difference in the specific gravity of heavily, medium, and lightly salted fish.

Trawlers began pickling fish from their first day of / 19 fishing and completed pickling operations ten days before they arrived at their shore base. Fish of different degrees of saltiness were simultaneously unloaded from a single trawler's hold, and it was extremely difficult to grade them according to the categories specified by the standard.

The State Institute for Design in the Fishing Industry (Giproryba), at the suggestion of the Murmansk Fishing Directorate (Murmanryba), developed a plan for an automatic unit which would grade fish according to three categories of specific gravity. In this unit, the fish was to pass successively through two tanks containing brine of different density and to be graded according to saltiness.

Attempts have been made to use hydraulic engineering for catching fish.

At fishing enterprises in the Caspian Basin N.S. Fershtut installed piles for trap nets by preparing the foundations with a jet of water, which accelerated and facilitated this laborious work by ten to twelve times.

As a result of work by the Caspian Branch of VNIRO, hydraulic engineering was applied to fishing for sprat with the aid of electric light. The Kamchatka Division of TINRO is developing methods of applying the hydraulic mechanization of catching fish with the use of fields of electric current.

Hydraulic engineering, then, has to such an extent expanded over a short period that it is to a large extent predetermining the paths of development of new technology in the fishing industry.

Chapter II

SPECIAL FEATURES OF THE APPLICATION OF HYDRAULIC ENGINEERING AT ENTERPRISES OF THE FISHING INDUSTRY

1. General Conditions for the Application of Hydraulic Engineering at Fishing Industry Enterprises

The conveying of fish and auxiliary materials at fishing /20 enterprises, and related transshipping operations, represent the most laborious processes in the fishing industry. This applies particularly to enterprises where the fish undergoes commercial processing, i.e., pickling and chilling. At fish plants that specialize in the commercial processing of fish and have purely transshipping and conveying tasks, the technological operations involved in the processing of the fish are closely interwoven. These operations include pickling proper, i.e, the powdering of fish with salt in a pickling vessel (barrels, vats or bins) or immersing fish in brine; canting - the mixing of fish in a pickling vessel in the process of salting down; unloading salted fish from vats; covering fish with crushed ice and placing it into boxes in batches of standard weight to which ice is added — along the rows, etc. These operations are either completed in the process whereby the fish are continuously conveyed, or by their very nature they are transshipment operations. Therefore any mechanization, including hydraulic mechanization of transport within a plant or shop is unthinkable without the simultaneous mechanization of the fish processing procedures themselves. The continuity of conveying and technological operations is essential; interruptions (unless they result from a technological necessity), or the inclusion of manual operations into a mechanized system, in all cases reduce the efficiency of mechanization.

Another important special feature of mechanization at fish enterprises is the fact that in transshipping, conveying and technological fish processing operations, the fish gradually changes its condition as it is moved around an enterprise: it is converted from raw fish at the beginning of the production process to a semifinished or finished fish product at the end of the process.

Movement is a characteristic feature accompanying the processing of fish. A properly planned mechanized line should ensure the continuous movement of fish through the operations involved in its processing and should not permit the formation of accumulations (bottlenecks and heaps of product forming obstructions) of fish at any one of these operations. /21

Hence there develops the concept of the mechanical cycles of fish plant production. In the course of its processing, the fish is moved from one mechanical operation to another until it undergoes chemical, heat and similar processing, after which this movement ceases; interruptions in the movement of the fish in fact define the beginning and end of the cycle. For example, the first cycle of mechanical operations and movement involves unloading, conveying, grading, weighing and pickling. A break in the movement occurs when the fish is lying in a vat. The second cycle includes unloading from vats, packing and putting in a warehouse; here there is a break in movement in which the fish is in the warehouse, and so on.

In accordance with the foregoing, the production of the fishing industry can be broken down into single-cycle, two-cycle, three-cycle and multicycle. For example, fish pickling plants have two- and three-cycle production, and canning and smoking plants, three- and four-cycle production.

For the purposes of determining the efficiency and output of mechanization, the division of production into cycles permits one to observe that the most important cycle is the first, i.e., that in which the fish is received for processing. This cycle includes the unloading of raw fish from fishing gear and transport ships, its conveying through the [plant] area to the place of primary processing, and the primary processing itself.

The most important feature of the mechanization at a fish processing enterprise is the acceleration of the processes of receiving the fish, i.e., of the tempo of work in the first cycle. The faster the fish is unloaded and processed, the higher will be the quality of the product, finished or semi-finished, and the faster the ships and fishing gear will be freed and sent back to fishing. Thus as a result of the all-around use of mechanization, and in particular hydraulic mechanization, catches of fish at fishing industry enterprises are increased, and the quality of finished and semi-finished products is improved. In addition, output per man-hour is increased, in consequence of which manpower is set free.

In a mechanized cycle, machinery and devices form a system which is bound together by a common productive capacity. In the first cycle at fishing industry enterprises the most important value in this system is the productivity of the first so-called leading unit. In a hydraulic engineering system at fishing industry enterprises the leading unit of the first cycle is the fish pumping installation.

The output, in quantity of fish, of the fish pumping installation is the value to which the output values of all the subsequent machinery and devices in the first cycle must compare.

The output of the leading unit in its general form is expressed by the equation

$$Q_{p_1} = K \cdot Q_m, \qquad [1]$$

where Q_{r1} is the fish output of the leading unit in tons per hour; /'22

Q_m is the standard or rated output of the leading unit in tons per hour;

K is the coefficient of use of the leading unit, depending upon time losses in mooring and casting off, upon weather conditions (storms and fog), and upon losses of time on unforeseen interruptions in the work owing to technical failures; ordinarily, K = 0.4 to 0.8.

Since the rating plates of fish pumps give their output when pumping pure water (in terms of water), for a case where the leading unit is a fish pump expression [1] can be written as follows:

$$Q_{p_1} = KQ_{в}\gamma_{в}\frac{i}{100}, \qquad [2]$$

where Q_{r1} and K are the same as in Formula [1];

Q_v is the output of the fish pump in terms of water (as on the rating plate) in cubic metres per hour;

γ_v is the density of the water in tons per cubic metre, which is usually taken as γ_v = 1 ton per cubic metre;

i is the average content of fish in a mixture, in percent; ordinarily, i = 10 to 30%.

From expressions [1] and [2] it follows that the less time lost, the greater will be the output of mechanization and its overall efficiency. Hence the necessity for continuity in the work both of the fish pump itself and of all auxiliary and subsequent devices.

Another, even more important, requirement of the mechanization of laborious procedures at fish processing enterpris is that the fish must be kept intact.

Fish is utterly unique as an object of hydraulic engineeri In all of its states, from its raw form to a finished product, it has the capacity of being damaged as a result of interaction with machinery. For example, when fish passes through a fish pump, its scales can be either completely or partially struck off, the head torn away, the bones of the skull crushed, fins torn off, etc. Hence the main difficulty in developing mechanis for the fishing industry in general and hydraulic mechanization in particular is that in mechanization systems the fish must not receive mechanical damage which could lower the grade of the finished product.

A properly installed and normally operating fish pumping installation causes no more damage than would result from the manual transshipping of the fish. This, however, has not been achiev at once, but rather as the result of a lengthy search for suitable designs.

The fish processing industry in most cases makes excep- / 23 tionally high demands of the outward appearance of raw fish that is arriving for treatment. For example, in the production of salt fish and in the processing of fish under refrigeration, the presence on the fish itself or on the finished product of defects of the external integument (abrasions, fragments of scale, breaks in the skin, tears in the meat, torn-off heads and fins, etc.) is reason for classifying fish that is perfectly good from the nutritional viewpoint as second or even third grade. In the smoking industry, outward damage to raw fish generally makes the latter impossible to accept for processing.

The physical characteristics of raw fish - specific gravity, bulk density, angle of rest, friction coefficient, the mechanical firmness of the fish and its individual parts (skin, fins, tissue, etc.) do not remain constant and change continually in the course of time. They differ to an even greater extent from the same physical properties of processed fish. Hence the necessity for a differentiated approach to fish in different sectors of the production cycle, and the considerable diversity of the operating conditions of mechanical equipment when it is performing similar operations in different areas.

The firmness of fish and its capacity for being damaged depend upon many factors. A live fish is supple and resilient. Shortly after death its body coarsens (becomes rigid), and then autolysis softens the tissues of the fish. The mechanical firmness of fish tissue drops sharply at the beginning of the salting process. When the saltiness of the fish is increased to more than 4 to 5%, the firmness of the tissue begins again to increase.

In tests of devices for mechanizing the unloading and conveying of fish at the Budennovskii Fish Plant at Astrakhan it was noted that the fish pump caused more damage to lightly salted fish (which was only beginning to be salted) than to fresh or heavily salted fish.

When frozen fish is thawed there is also a sharp reduction in the firmness of its tissue. In fresh and even live fish the firmness of the body changes in relation to the season. The Volga roach proceeding to spawning in the spring, is much firmer than a summer roach.

When any kind of mechanical equipment is being selected, these peculiar characteristics of fish must be taken into consideration. In any case, no device must be used without a preliminary check of the manner and extent to which the fish can be damaged. Here the purpose of checking is to determine the operating conditions of a fish pump or other equipment under which damage to fish is either reduced to a minimum or entirely eliminated.

The most favourable operating conditions of a fish pump combine minimum damage to fish with the required lift. For example, in RB-100 centrifugal fish pumps, where the speed of the wheel is 1,450 rpm, the extent to which medium-sized fish (herring and small run-of-the mill fish) are damaged is extremely / 24 great. When the rpm of the wheel is reduced to 520, there is a sharp drop in the rate of damage to the fish. At the same time, the output of the fish pump is reduced, and the head drops to 3 metres, which greatly hinders the further conveying of the fish, since with such a head value it is in most cases impossible to use a hydraulic conveyor, and a conversion must be made to dry methods - conveyors, wagons, etc.

In water-jet pumps, the creation of operating conditions that are harmless for fish requires a reduction in the power of the jet in the mixing chamber, i.e., a reduction in the suction height. Thus for large run-of-the-mill fish the suction height is only 2.5 metres.

The density of the working mixture of water and fish also affects the extent to which fish may be damaged. The thicker the mixture, the greater the damage done to the fish. A fish-to-water ratio of 1:2 to 1:10 must be considered an acceptable composition. In practice, frequent use is made of a mixture with a composition of 1:3 to 1:4 (the denominator represents the fish, and the numerator, the water). An increase in the density of the mixture results in an increase in the fish output of the pump, hence the tendency of workers to operate with a dense mixture is understandable.

Thus finding the most favourable operating conditions for a fish pump requires that numerous factors be taken into account, and is possible only as the result of experimental work in each individual case. The same applies to fish conduits of both the pressure and the trough type.

The above difficulties in applying hydraulic engineering at fishing industry enterprises are to a considerable extent exceeded by the advantages created by hydraulic engineering in cases where satisfactory operating conditions have been found for the equipment. In contrast to "dry" mechanization facilities, hydraulic engineering permits the majority of operations with fish in the processes of receiving, unloading and conveying to be performed in liquid agents(in water or brine), which are the most conducive to keeping the fish in good condition.

Only hydraulic engineering is capable of ensuring the delivery and processing of fish, live or otherwise, in the freshest form. Herring, for example, which is caught with trap nets off Sakhalin is delivered to the shore live in net bags, is pumped out by fish pumps and is conveyed live along a system of hoses, pipes and troughs to the pickling shed; a high-quality product is thus ensured. Similar hydraulic engineering systems have been developed for fish of the salmon family in Kamchatka, for Baltic herring and for Caspian sprat.

Of great value is the fact that in hydraulic engineering systems the conveying medium is at the same time a cleansing agent. Thus when it emerges from the system, the fish is not only uncontaminated and not covered with harmful microflora (the reverse is true when it is transferred on a conveyor belt or in a cart), but is washed clean of slime, loose scales, sand, mud and other impurities. /25

The overall sanitary state of production at fishing industry enterprises which have been provided with hydraulic machinery, where equipment is properly operated, is better than where non-liquid conveying machinery is employed, and especially better than where operations are performed manually.

Finally, where hydraulic engineering has been applied, the greatest output may be developed in the first cycle, in which the fish is received from the fishermen, since leading units including fish pumps and other hydraulic engineering devices unload fish many times faster than non-liquid machinery (cranes, booms and conveyers [x]) used for the same purpose.

2. Fish Firmness

Fish consists of elements that differ considerably from each other in their structure and mechanical firmness. The structural foundation of a fish is its skeleton, which is a semirigid structure possessing a certain flexibility in a longitudinal horizontal plane. On the skeleton, arranged in layers, are muscle tissue, layers of fat, and skin which differ in toughness, but all of which together increase the toughness of the fish particularly under shock loads, cushioning impacts by their resiliency.

Individual parts of a fish's body operate in different ways under various conditions. Thus, for example, a fish moving in a stream of water along a hydraulic conveyor and coming into contact with rough or cutting surfaces can receive cuts and abrasions. In this case, only the skin of the fish and the closest subcutaneous layers operate in taking up the strain. When it is at the bottom of a bin and is sustaining pressure from the weight of upper layers, the fish resists crushing. In this case, the entire structure of the fish's body, i.e., the skeleton and the muscle tissues, acts. In such a situation, the softest parts of the fish's body, for example the abdomen, frequently do not withstand the pressure and burst[1], whereas the more rigid parts of the fish's body - the skeleton and, in particular the vertebra - remain completely uninjured. When passing through a centrifugal fish pump and leaving the operating wheel with considerable velocity, the fish is thrown back by centrifugal force and strikes the housing of the fish pump. If the shock load is taken up by the tail, i.e., the most flexible area, or the lateral part of the fish, where the skeleton is well protected by cushioning layers of muscle tissue, even where the fish pump wheel is revolving rapidly the fish will in most cases remain undamaged. If the shock is received frontally by the head of /26 the fish, the brittle bones of the skull, which are covered with very thin layers of muscle tissue and are therefore poorly protected from shocks, will be crushed. If the blow strikes the head of the fish from the side with sufficient force, the head of the fish can be broken off, the rupture occurring, as a rule, at the place where the skull is fastened to the vertebra, i.e., at the point of the weakest connection.

---

[x] Translator's note: this term is a suggested translation of the Russian stellingi, for which no other suitable equivalent is available.

---

[1] Perforation of the walls of a fish's abdomen (a burst fish) is usually the result of softening (digestion) of the walls of the abdomen by the digestive juices of the fish. This defect occurs more frequently in fish caught during the period of intensified feeding than among roed fish, although in the latter the walls of the abdomen are usually thinner and less firm.

Of practical value for hydraulic engineering is not the overall toughness of the fish, but the sturdiness of its individual parts under various loads. Of the greatest importance under shock loads are the solidity with which the head is attached to the trunk, and the toughness of the bones of the skull; where there is friction against rough surfaces, the toughness of the skin is most important.

The study of the toughness of fish, and in particular of the toughness of parts of their bodies in the three cases above, is only beginning, and there has been virtually no work in this field. Designers of fish filleting machines (G.A. Nikitin and A.I. Kapustyanskii) have studied the firmness of fish bodies when they are cut, and the Mechanization Laboratory of VNIRO (P.I. Gusev) is carrying out similar investigations, but their data have not been applied to the hydraulic mechanization of conveying operations at fishing enterprises. The research conducted by A.V. Terent'ev for the purpose of determining the solidity with which the head is attached to the trunk in various fishes under a shock load is of some value for hydraulic engineering.

The work T_{kr} expended in breaking off the head of a fish under a shock load has been investigated. This value has been included in a formula from which is determined the safe number (for fish) of revolutions of the operating wheel of a fish pump (see Chapter IV).

Fishes of various species, sizes and consistencies have been tested: frozen bream, frozen pike-perch, large, small, and medium-sized salted herring and live catfish.

The first problem raised was to determine the force necessary to crush a fish, from which data could be obtained for calculating critical stresses for fish. It was proposed to discover this force by bursting a fish on a press which would record the bursting stress. The first experiment, however, showed that it was not possible to grip the fish in the fastenings of the press, since it either slipped out of the clamps before the bursting stress was reached, or its tissues disintegrated in the clamps. Subsequently, therefore, experiments were conducted only on the breaking off of the head.

For this purpose an impact tester (see Fig. 5), which operated on the principle of a pendulum, was used. A round arm, on the end of which was fastened a weight in the form of a disk with a notch, oscillated in a vertical plane. Deep in the notch was a triangular block. On the oscillation axle of the pendulum was fastened a ratchet on which was made a graduated scale showing to what angle the pendulum swung. The latter was secured / 27
in a raised position by a toothed arm engaging in the teeth of the ratchet. When pressure was exerted on the arm, the pendulum was

freed and the weight went into motion. The specimen being tested was fastened at the bottom point of oscillation of the pendulum in the path of the weight. The pendulum struck the specimen with its block and crushed it.

When raised to its highest point, the pendulum accumulated a reserve of energy equal to 75 kilogram-metres. This energy was expended on overcoming all of the resistances acting during its oscillations. If there were no resistances, the pendulum would swing to the left to the same angle to which it was raised to the right of the vertical axis. Since, however, work was expended on overcoming the resistance of the atmosphere, the friction in the pivots and the crushing of the specimen, the pendulum swung to a lesser angle. The graduated scale recorded the angles of oscillation of the pendulum. Knowing the angle of oscillation and using the tables that were with the impact tester, we obtained the work of crushing the specimen in kilogram-metres.

The fish were fastened in various positions so that the blow of the block would come either on the occiput at the place where the head was attached to the vertebra, or on the throat. When catfish were tested, the blow was applied to the gills, since the head of the specimen did not go through to the recess of the striking part of the pendulum.

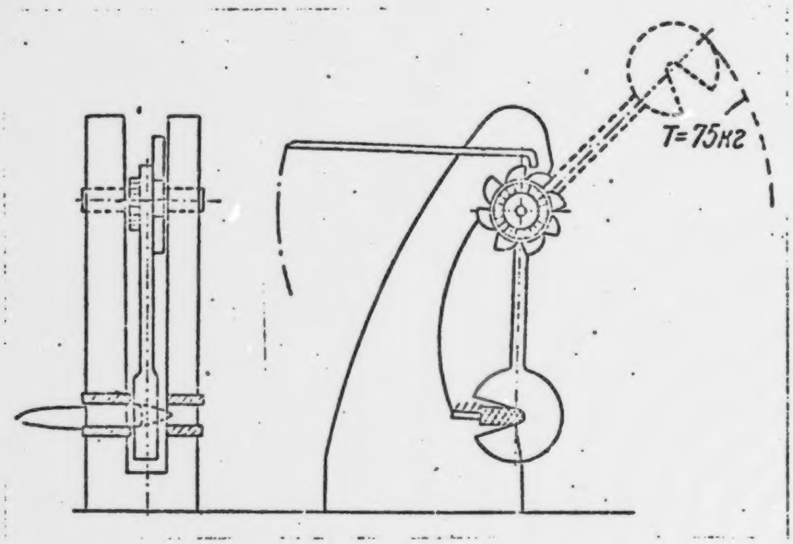


Figure 5 - Diagram of the action of an impact tester for testing the firmness of fish.

In some cases the head was not broken off, which was explained by the incomplete fastening of the fish, which under the effect of a blow causing it to bend was slightly crumpled and slipped out of the clamps.

Forty-three tests were made. This quantity cannot be / 28 acknowledged as sufficient for a final judgment concerning the toughness of fish, but initial data for basic calculations have been obtained.

The observations showed that the larger the fish specimen being tested, the greater was the work expended in crushing. When the impact tester struck the throat of a herring, the work of crushing remained the same as when the fish was struck on the occiput. For bream and pike-perch there was more work expended in crushing with a blow on the occiput than on the throat. This latter observation agrees with observations, under actual conditions, of fish that have been transferred with a fish pump: ruptures of the throat are found more frequently than ruptures of the occiput.

The relationship between the sizes and the weight of the fish that were tested and the value of the crushing work may, with sufficient accuracy for technical calculations, be considered as proportional to the weight for every species of fish when it is in any condition (see Fig. 6).

The absolute values of the crushing work in the experiments that were performed fluctuated from 2.2 (for soaked, salted herring) to 35 kilogram-metres (for live catfish). These observations indicate the effect of the saltiness of fish on its firmness. It may be assumed that freezing and thawing also affect the degree of firmness of a fish's body.

Data for calculating the operating conditions of centrifugal fish pumps can be obtained from an experiment on determining the firmness of fish. It is evident that for each species of fish, depending upon its size, weight and conditions, the operating conditions of a fish pump must be individual and specially studied in each separate case, since the value of the work expended in /29 crushing fish alters within extremely wide limits.

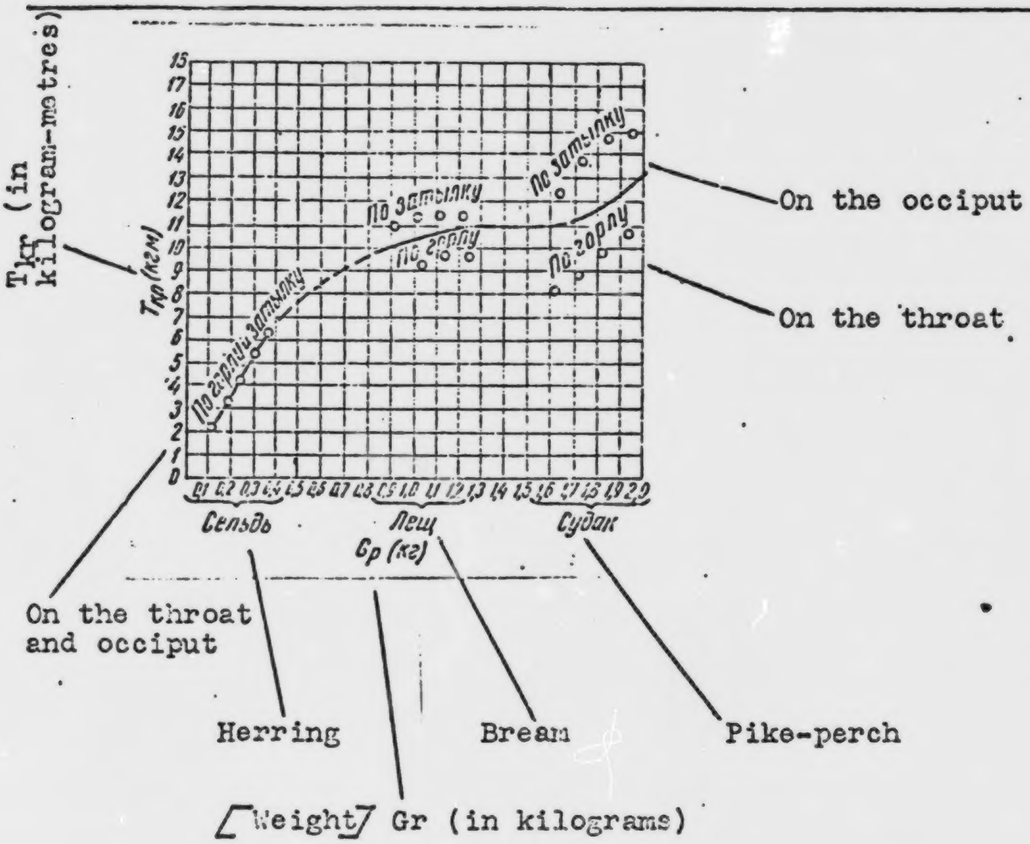


Figure 6 - Graph of work expended in crushing a fish with an impact tester

In order to obtain data which would guarantee good work by a fish pump, recourse was had to an artificial method: the weight of the fish was taken as maximum, and the work of crushing, as average. In this instance, the ratio of the work of crushing to the weight of the fish, which we shall call the characteristic ratio, was calculated for certain species of fish.

The amounts of these calculations are given in Table 1.

Table 1

Character of Firmness of Certain Fish

Name of fish	Weight G_r of one fish, in kg	Average work of crushing T_{kr}, in kilogram-metres	Characteristic ratio $R = \frac{T_{kr}}{W_r}$
Salted Caspian herring (black-backed shad)	0,450	4,57	11,26
Thawed pike-perch	1,820	12,85	7,06
Thawed Azov bream	1,150	10,36	9,00
Sheatfish (live)	2,300	28,56	12,50

The data in Table 1 can be used for calculating the operating conditions of centrifugal fish pumps.

No systematic research has yet been carried out on the effect of pressure on fish. Tentative permissable pressure values for fish of various species and conditions can be recommended on the basis of a series of practical observations.

Species and condition of fish	Permissible pressure in kg/cm^2
Fresh raw anchovy under a steady load	0,20
Fresh raw anchovy in a stream (fish conduits under pressure)	1,60
Raw anchovy retained under a steady load	0,05
Fresh Caspian herring under a steady load	0,2–0,3
Salted Caspian herring under a steady load	2,5
Fresh Pacific sardine under a steady load	0,1–0,12
Raw, fresh tiulka. in a stream	1,0
Large, fresh, raw run-of-the-mill fish under a steady load	0,4
Small, raw run-of-the-mill fish retained in a stream	0,4

A.V. Kan, S.I. Gakichko and others have observed the / 30 effect of a vacuum of 8 metres of water on the following heavily salted fish: roach, Astrakhan herring, Murmansk herring, and Pacific sardine. During the observations, no mechanical changes were noted in the bodies of the fish, in particular their internal organs - the swim bladder, roe, etc. Hence it follows that in fish pumping installations, the vacuum in whose intake hoses is actually much less than eight metres of water, the vacuum created by the fish pump cannot cause mechanical damage either to the fish itself or to its internal parts.

3. Physical Characteristics of Some Fish

Until recently, neither the physical characteristics of fish from the viewpoint of mechanization nor fish firmness has been studied systematically or in sufficient breadth. Systematic studies in this field include those of N.M. Balanin, Belousov, and Engineer Sbitnev on the specific gravity, bulk density and coefficient of friction of fish of certain species that are themselves in certain states, and so on. The VNIRO Mechanization Laboratory has conducted a series of systematic investigations in this field since 1952. This work is still far from completion; therefore, the physical characteristics of fish as an object of mechanization have had to be collected until now from disconnected sources.

In the tables below is given an extract from studies by N.M. Balanin, VNIRO, and its branches. In these tables, in some instances, data on the greatest transverse sizes of fish are given from Soldatov's book, Commercial Ichthyology.

The linear sizes of some fish are given in Table 2 for calculating the limit of applicability of centrifugal fish pumps (see Chapter IV).

The specific gravity and bulk density of fish (see Table 3) must be known in order to make calculations for measuring bins and pickling vessels.

The angles of rest of fish are given in Table 4, and the coefficients of friction of fish of various species and in various states, in Table 5, for calculating the angles of incline of gravity spouts, water separator gratings and the sloping bottoms of bins.

The accumulation of knowledge regarding the physical characteristics of fish as an object to be conveyed and processed has brought about the necessity for generalizing this knowledge and determining the mathematical relationships among individual indices, for example, among the length and weight, weight and fatness, and weight, length and fatness of fish, and so on. Thus G.N. Monastyrskii has proposed for various fish species a universal formula which links the length, fatness, height (width) and weight of the fish:

$$G_p = c \cdot L \cdot S \cdot H, \quad [3]$$

Table 2 /31

Linear Sizes and Weight of Raw Fish

Species of fish	Full length in cm	Greatest transverse size, in cm	Weight of one fish, in g
Tiulka	5–9	1,5–1,6	2,4–2,9
Azov anchovy	6,2–12,5	1,0–1,9	5,0–7,5
Common Caspian kilka (sprat)	7,7–11,6	1,3–2,2	3,0–8

Table 2 (cont'd)

Species of fish	Full length in cm	Greatest transverse size, in cm	Weight of one fish, in g
Caspian anchovy-like kilka (sprat)	9,3–13,8	1,5–2,4	3,9–14,4
Baltic sprat	11–13	—	10–14
Kaliningrad spring Baltic herring[1]	16–32	2,9–3,8	20–89
Pacific sardine	18–21	—	70–110
Caspian shad	18–21	—	100–120
Pacific Sakhalin herring	20–35	—	100–400
Volga shad	26,6–32,4	—	159–355
Black-backed shad	39,3–41,7	До.12	866–975
Mullet	25–27	—	60–1350
Pink salmon	42–52	—	500–1000
Sockeye salmon	56,9–66,5	—	2300–3400
Chum	72–75	—	4100–4900
Chinook salmon	78–103	—	5500–17000
Caspian pike	47–54	11–12	900–1100
Azov roach	12,5–38	—	200–400
Caspian roach	21–25	8,0–9,4	150–300
Caspian bream	34–41	10–11	380–700
Caspian carp	44,6–49,5	13,0–14,7	1100–1270

---

[1] The herring of other regions of the Baltic is smaller and lighter than the Kaliningrad variety.

Table 2 (cont'd)

Species of fish	Full length in cm	Greatest transverse size, in cm	Weight of one fish, in g
Kutum (*Rutilus frisii kutum*)	38–52	—	830–2100
Caspian pike-perch	43–51	12–14	900–1200
Barents Sea cod	40–80	—	1000–5000
Pacific cod	70	—	4000–5000
Baltic cod	24–107	—	110–1000
Coalfish	60–70	—	До 7000
Arctic cod	18–22	—	50–60

Note. This table contains data on the fish most frequently found in large quantities in commercial fisheries; individual specimens of fish of all species can deviate considerably from the data shown.

---

where G_r is the weight of the fish /32

c is the numerical coefficient characterizing the species of fish;

L is the length of the fish;

S and H are the fatness and height of the fish measured at a distance of 0.44 L from the end of the snout.

Table 3

Specific Gravity and Bulk Density of Fish

Name of fish	Bulk density of fish, in tons per cubic metre				Specific gravit of dead fis
	live	dead	salted	frozen	
Spring tiulka	—	0,80 - 0,85	—	—	1,015—1,027
Azov autumn anchovy	—	0,92 - 0,93	—	—	1,035—1,047
Common Caspian spring kilka (sprat)	—	0,8 —0,92	—	—	1,018 —1,032
Anchovy-like Caspian summer kilka (sprat)	—	0,83—0,9	—	—	0,96 —0,98
Kaliningrad spring Baltic herring	—	0,91—0,94	0,87	—	1,036—1,053
Ungraded Astrakhan herring	—	0,80	0,77	—	1,04
Astrakhan shad	—	0,84	0,79	—	—
Pacific sardine	—	0,79—0,85	—	—	1,04 —1,05
Sakhalin spring herring	—	0,91	—	—	1,02 —1,05
Astrakhan roach	0,81	0,79	0,71	0,44	—
Spring kutum	—	0,81	—	—	—
Astrakhan bream	0,80	0,77	0,58	0,42	—
Azov spring bream	—	0,79	—	0,44	—
Astrakhan carp	0,75	0,74	—	0,46	—

Table 3 (cont'd)

Specific Gravity and Bulk Density of Fish

Name of fish	Bulk density of fish, in tons per cubic metre				Specific gravity of dead fish
	live	dead	salted	frozen	
Astrakhan pike-perch....	0,71	0,69	0,67	0,41	—
Azov spring pike-perch..	—	0,75	—	0,42	—
Chum..................	—	0,84	—	—	1,01 –1,07

For Sakhalin herring L.N. Menshutina gives the formula

$$G_p = aL - b, \qquad [4]$$

where G_r and L are the same as in Formula [3];

a and b are numerical coefficients.

For Baltic herring B.F. Novitskii gives a formula linking the length and weight of the fish:

$$G_p = aL + bL^2 + cL^3, \qquad [5]$$

where a, b, and c are numerical coefficients

For common Caspian kilka more than 80 mm long A.Ya. Kashirskii gives the function

$$G_p = 2{,}7L - 18{,}2, \qquad [6]$$

Table 4

Name of fish	State of fish			
	live	dead	salted	frozen
Tiulka	—	37–42	—	—
Azov anchovy	—	28–30,5	—	—
Common Caspian kilka	—	36–42	—	—
Kaliningrad Baltic herring	—	16–26	—	—
Caspian black-backed shad	—	23,5	24	—
Run-of-the-mill Caspian herring	—	24,5	—	—
Ungraded Caspian herring	—	25,5	28	—
Sakhalin herring	—	3–17	—	—
Ungraded shad	—	26	29	—
Roach	34	37,5	27	51
Astrakhan bream	15,5	17	30	30
Astrakhan pike-perch	31	34	35,4	59,5
Carp	24	34	—	51,5

where G_r is in grams and L is in centimetres.

Thus common regular patterns of the relationship of the weight of a fish to its linear dimensions have so far not been derived. This is explained by the fact that various investigators have worked with different fish. Moreover, it should be borne in mind that a fish and its physical characteristics change continuously not only from /36 specimen to specimen, but also from month to month and from year to year (the fish diminishes in size, grows thin or fattens, etc.) depending upon changes in the conditions of its habitat.

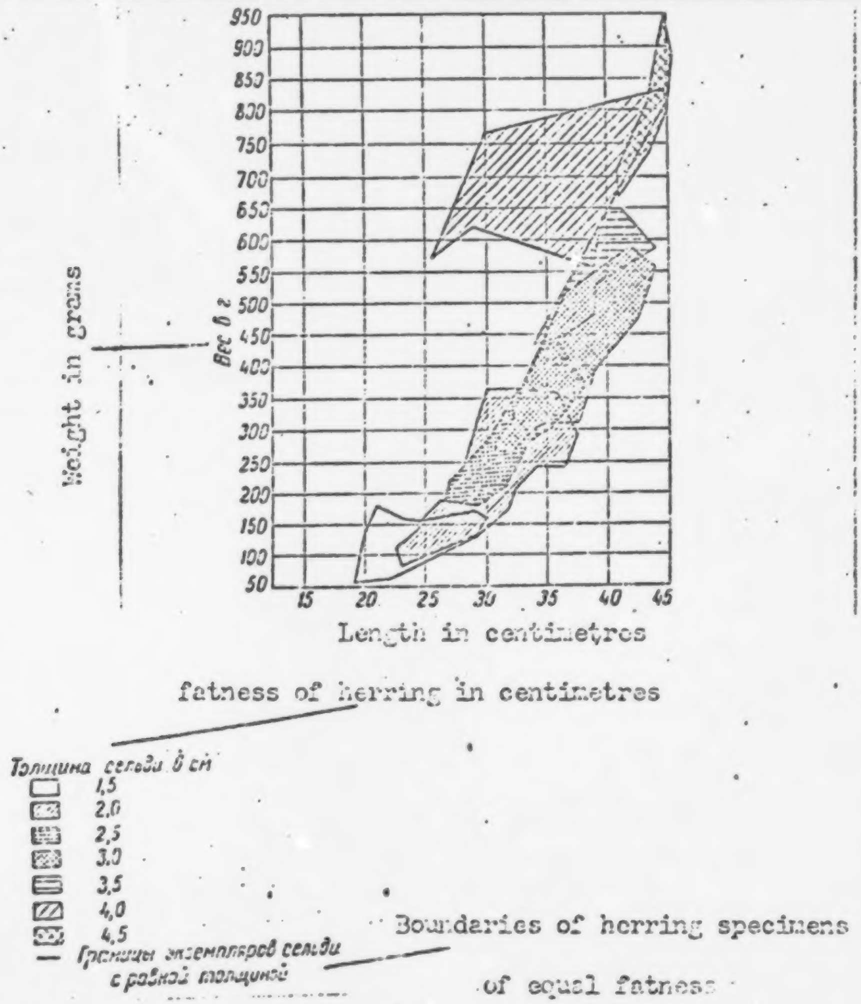


Fig. 7 Data on linear dimensions of salted Caspian herring.

All of the derived mathematical functions, even those on identical material, are inexact and are to a certain extent conditional. V.V. Dormenko demonstrated this for salted Caspian herring when he constructed in the axes of coordinates a diagram of the fields of distribution of fish of different fatness from the results of numerous (more than 500) measurements. It may be seen from Fig. 7 that given the same length and weight, the fatness of fish (i.e., their greatest thickness) varies within wide limits.

4. Auxiliary Materials and Waste Products in Hydraulic Engineering Systems at Fishing Enterprises

Salt and salt solutions

In hydraulic engineering systems for the fishing industry salt is used mainly for preparing brines, i.e., aqueous solutions of salt. In its dry form salt is used only in mixed systems, where hydraulic engineering is combined with mechanization using "dry" methods, and in this case is used directly for pickling fish.

Table 5

Coefficients of Friction of Fish of Various Species and Conditions

Species name and state of fish	On wood			On iron			On a conveyer belt		
	dry wood	wood moistened with water or brine	wood covered with slime	dry iron	iron moistened with water or brine	iron covered with slime	dry belt	belt moistened with water or brine	belt covered with slime
Dead black-backed shad	0,60–1,33	0,51–0,75	0,31–0,55	0,38–0,84	0,32–0,67	0,23–0,70	0,81–1,23	0,22–0,73	0,36–0,67
Run-of-the-mill dead Caspian herring	0,9 –1,96	0,65–1,38	0,4 –0,90	0,67–1,28	0,40–0,84	0,29–0,73	0,75–1,43	0,58–0,97	0,53–0,90
Dead Sakhalin herring	—	1,04–2,15	—	—	0,49–0,67* 0,84–1,33**	—	—	1,0 –1,07	—
Dry-frozen black-backed shad	0,34–0,42	—	—	0,27–0,38	—	—	0,32–0,38	—	—
Dry-frozen run-of-the-mill herring	0,31–0,49	—	—	0,27–0,42	—	—	0,36–0,47	—	—
Salted Sakhalin herring	—	2,25–4,01	—	—	1,0 –1,11* 1,38–1,73**	—	—	2,15–3,73	—
Ungraded dead shad	0,73–2,05	0,65–1,19	0,45–1,48	0,58–0,87	0,45–0,84	0,42–0,84	0,87–1,80	0,75–1,15	0,65–1,15
Live, ungraded roach	0,84–1,80	1,00–1,48	0,70–1,19	0,51–1,11	0,75–0,93	0,73–1,00	0,81–1,51	0,78–1,10	0,65–1,28
Dead, ungraded roach	0,75–2,05	0,49–1,19	0,45–0,78	0,51–0,19	0,42–0,70	0,45–0,67	0,67–1,19	0,70–1,15	0,70–1,11

Table 5 (cont'd)

Species name and state of fish	On wood			On iron			On a conveyer belt		
	dry wood	wood moistened with water or brine	wood covered with slime	dry iron	iron moistened with water or brine	iron covered with slime	dry belt	belt moistened with water or brine	belt covered with slime
Ungraded roach, lightly salted package*	0,70–1,11	0,65–0,97	—	0,55–0,75	0,51–0,75	—	0,75–1,28	0,67–1,19	—
Dry-frozen ungraded roach	0,34–0,55	—	—	0,27–0,47	—	—	0,34–0,60	—	—
Live, ungraded bream	1,28–1,80	0,84–1,60	0,36–0,81	0,42–1,00	0,29–1,29	0 19–0,53	0,62–0,88	0,55–1,33	0,45–0,78
Dead, ungraded bream	0,81–1,43	0,53–1,15	0,36–0,70	0,58–0,97	0,27–0,70	0,23–0,49	0,62–1,15	0,58–1,00	0,58–0,87
Ungraded bream, lightly salted package	0,75–1,33	0,67–1,15	—	0,60–0,97	0,53–0,78	—	0,81–1,19	0,75–1,28	—
Dry-frozen ungraded bream	0,45–0,60	—	—	0,36–0,58	—	—	0,38–0,55	—	—
Wet-frozen ungraded bream	—	0,42–0,51	—	—	0,32–0,45	—	—	0,40–0,55	—
Dead pike-perch	1,43–1,96	0,65–2,14	0,45–1,28	0,49–1,00	0,47–0,62	0,32–0,62	0,67–1,80	0,90–0,66	0,62–1,66
Dry-frozen ungraded pike-perch	0,45–0,58	—	—	0,40–0,47	—	—	0,45–0,58	—	—
Live, ungraded pike-perch	0,84–1,88	0,38–0,81	0,29–0,49	0,34–0,58	0,34–0,49	0,32–0,45	0,55–0,84	0,62–0,90	0,53–0,75

---

*Translator's note. A suggested rendition of the Russian kolodka, for which no other suitable equivalent is available.

---

* Tinplate
** Iron rods

Table 5 (cont'd)

Species name and state of fish	On wood			On iron			On a conveyer belt		
	dry wood	wood moistened with water or brine	wood covered with slime	dry iron	iron moistened with water or brine	iron covered with slime	dry belt	belt moistened with water or brine	belt covered with slime
Dead, ungraded pike-perch........	0,58–1,07	1,45–0,78	0,31–0,53	0,51–0,70	0,49–0,60	0,40–0,60	0,73–0,87	0,65–0,84	0,70–0,87
Dry-frozen ungraded carp.........	0,55–0,67	–	–	0,34–0,49	–	–	0,51–0,58	–	–
Samll fish - Baltic sprat and Baltic herring..............	Virtually do not slip on any materials at angles of inclination of up to 90°; when moved with water and by being agitated they slip at angles of 20° to 45°.								

Brines are intended for salting down fish and are also used as a conveying fluid in hydraulic conveyers. This latter use of brine is possible in all cases where fish that is either salted or destined for pickling enters a hydraulic engineering system. Here a hydraulic conveyer is frequently termed a brine conveyer.

In contrast to water used in conveying, which is for the most part used only once in a hydraulic conveyer, and after passing through water separators is dumped into a sewer system, brine used for the same purpose, after it has been regenerated and purified, again enters a pump which feeds it into the hydraulic conveyer for use once more. Thus the brine circulates in a closed system: pump - hydraulic conveyer - water separator - regenerator (salt concentrator) - pump. In hydraulic engineering systems, therefore, brine is frequently termed circulating brine, particularly if it serves as a reagent salting down the fish.

Concentrated brines, i.e., saturated salt solutions with an NaCl content of 25.4% and a specific gravity of 1.2 or 23.4° Baume, are mainly used in hydraulic engineering systems. Common salt, used for pickling at fish plants, is employed for preparing brine.

Regeneration of the brine takes place in salt concentrators and consists of the following:

1) by means of a filter the brine is cleansed of mechanical impurities - scales, slime, sand, bits of fish, etc., which have gotten into it during the salting down or conveying of fish;

2) the salt loss in the brine is made up that occurs owing to the salting down of fish and the incorporation by the solution of extraneous moisture in the fish; the salt solution is brought to full saturation.

In addition to moisture, various nitrogenous substances get into brine that is in contact with fish. As a result, the brine foams. Brine that has been used many times has a high capacity for foaming, which greatly hinders its utilization. In order to keep brine from foaming, it should not be permitted to fall freely or spray in the air.

Saturated brine is a preserving fluid; it can therefore be stored and used for an extremely long time. Inspections of the quality of circulating brine used for pickling herring at the Pervomaiskii Fish Plant in Dagestan, at the Klerk Fish Plant in the Soviet Maritime Territory and at fish plants on Sakahlin, have demonstrated that brine used repeatedly for over two months did not in this time acquire any putrid odor or taste and was entirely suitable for further use. /38

Freshly prepared brine is of a yellowish-greenish colour with hues ranging from the palest of these colours to a fairly strong intensity.

The initial colour of fresh brine depends upon the quality of the salt and water that have gone into its preparation. Brine that is used repeatedly and is saturated with organic substances is of a colour ranging from turbid yellow and sandy to dark red and Bordeaux.

River or sea water with no other special preliminary purification than that which exists in the water supply systems of a given enterprise, is used for preparing brine, depending upon the area in which the fish plant is situated.

Data on the bulk density of salt of various origins is given below.

Name of salt	Bulk density in kilograms per cubic metre
Iletsk	1274
Baskunchak No. 1	1266
Baskunchak No. 2	1257
Baskunchak, superior grade of crystals	1030
Pavlodar	1200
Aral	1086
Usol'e	1025

Salt transshipment operations occupy a prominent place at fishing industry enterprises. Proposals have recently been made that hydraulic engineering be applied to the transshipment of salt. In Kamchatka

N.F. Chernigin has proposed to transship salt to shore from ships standing in a roadstead with pumps in a stream of saturated brine. In this system, a hose is laid from the ship (where a pump has been installed) on floats to the shore, where there is a drainage facility and a second pump which feeds the liberated brine through a second hose to the ship.

This proposal has not been applied in practice. If, however, it were realized, it would permit a sharp curtailment in the time taken to unload salt from ships and would also reduce losses of salt, which reach considerable proportions in roadstead transshipments.

Ice

There exist many different schemes, which rest on technical calculations and stipulate the conveying of crushed ice in a stream of water in tubular and trough hydraulic conveyers.

The main reason for objections to the realization of such /39 a method of conveying ice is the apprehension that there will be considerable losses from melting of the ice in the stream of water, since the temperature of the water is higher than the melting point of the ice. In order to decrease losses of ice, plans have been made to use the conveying water repeatedly and to reduce its temperature to 2 to 3°.

According to the calculations of some authors (A.E. Nitochkin and others), losses of crushed ice, it it were conveyed in a trough under summer conditions at Astrakhan, would not exceed 5 to 10%.

The specific gravity of ice is 0.88 to 0.92 g/cm^3, and the bulk density of crushed ice, 0.8 tons per cubic metre.

Fish waste

Hydraulic engineering can be applied to fish waste at fish processing enterprises.

Fish waste is used for conversion into fodder meal and fertilizer; oil is also melted out of it. Where fish is canned, waste comprises about 40% of the weight of the fresh fish. The flow of waste, however, is not heavy and rarely amounts to more than 5 to 10 tons per hour.

The advantages of applying hydraulic engineering to the conveying of waste include a high level of hygiene, due to the continuous washing of all facilities by the conveying water, and the possibility of conveying the waste using pipes buried in the ground.

There is fear that where hydraulic mechanization is used for conveying waste, the nutrient substances from the conveyed waste will be dissolved out by the water and that large quantities of fish particles and undersized fish will be carried away by the outgoing water. These apprehensions, however, have not been confirmed by practical data.

Scale

Some fish (anchovy, tiulka and herring) very easily lose all of their scales in hydraulic mechanization systems. Others, for example, large run-of-the-mill fish, lose their scales only partly.

The presence of scales in conveying liquids has a harmful effect on the operation of water separators. Scale in most cases contains a large amount of adhesive substances, and when it falls on the gratings of water separators, it stops them up, as a result of which the capacity of the water separators is sharply reduced.

Scale is used for preparing glue. The most valuable element of scale, however, is guanine, which exists on the scale in the form of a nacreous or silvery layer. Pearl paste is prepared from crystalline guanine. In view of the value of scale, all water separating devices employed in hydraulic engineering should be supplied with scale traps.

Chapter III

WATER-JET FISH PUMPS

1. The Operating Principle of a Water-Jet Pump

Water-jet fish pumps are ejectors and operate on the /40 basis of D. Bernulli's principle, the essence of which is that where the flow rate and continuity of a stream of liquid flowing through a pipe with a variable cross section are constant, the pressure in the constricted part of the stream is less than in its normal cross section.

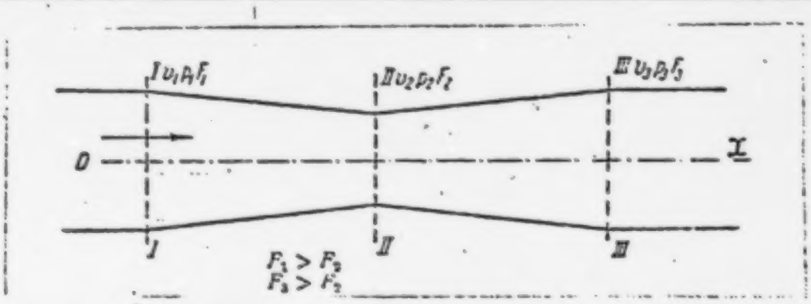


Figure 8 - Diagram of the flow of liquid through a pipe with a variable cross section

Suppose that an ideal liquid, i.e., a liquid moving in the manner of a laminar flow, with no internal friction among particles and undergoing no friction against the walls of the pipe, is moving in a continuous stream through a pipe with a variable cross section. The flow rate of this liquid is constant. The cross section of the pipe changes in such a way that for three sections taken arbitrarily, I-II, II-II and III-III (see Fig. 8), there exists the disparity

$$F_1 > F_2 < F_3, \qquad [7]$$

where F_1, F_2, and F_3 are the areas of the corresponding sections.

At the same time, the following equation is valid for the entire pipe:

$$Q = v_i F_i = \text{const}, \qquad [8]$$

where Q is the flow rate of the liquid in any section;

F_i and v_i represent the area of a certain cross section and the velocity of the liquid in this section.

Bernulli's principle for any cross section is expressed by the equation /41

$$\frac{v^2}{2g} + \frac{p}{\gamma} + z = \text{const}, \qquad [9]$$

where v is the velocity of the stream in a given cross section of the pipe in metres per second;

g is the acceleration of the force of gravity, equal to 9.81 m/sec^2;

p is the static pressure in the same cross section in tons/m^2;

γ is the density of the liquid flowing through the pipe, in tons/m^3;

z is the specific potential energy of the position of the liquid in the pipe in relation to the plane of comparison, in metres.

In expression /9_7 the first term represents the specific kinetic energy of the flow, and the second and third terms, the specific potential energy of the pressure.

Thus Bernulli's equation, which is one of the expressions of the law of conservation of energy, demonstrates that the total energy of the flow of an ideal liquid moving through a tube with a variable cross section, remains constant and consists of the kinetic energy of a mass of liquid moving with a speed v, the energy of the external static pressure, and the energy of the position of the liquid relative to the plane of comparison.

When we have drawn up Bernulli's equations for sections I-I and II-II and compared them, we obtain the following expression for a real liquid, i.e., a liquid subjected to the action of the forces of internal friction against the walls of the pipeline:

$$\frac{v_1^2}{2g}+\frac{p_1}{\gamma}+z_1=\frac{v_2^2}{2g}+\frac{p_2}{\gamma}+\Sigma h_w, \qquad [10]$$

where v, p, and z are the same as in Formula [9];

$\sum h_w$ is the sum of the losses of energy on friction when the liquid passes from section to section.

We assume that the axis Ox, which lies in the plane of comparison, coincides with the centre of the pipe; hence $z_1 = z_2 = 0$. We assume that in the short sector between sections I and II the losses on friction $\sum h_w$ are so low that they may be disregarded. We then get the equation

$$\frac{v_1^2}{2g}+\frac{p_1}{\gamma}=\frac{v_2^2}{2g}+\frac{p_2}{\gamma}=\frac{v_3^2}{2g}+\frac{p_3}{\gamma}=\text{const.} \qquad [11]$$

In the equation that we have obtained, the sum of the two terms $\frac{v_1^2}{2g}+\frac{p_1}{\gamma}$ can retain a constant value only on condition that if there is an increase in v_1, there will be a decrease in p_1 (the values 2g and γ are constant), and, vice versa, if v_1 decreases, p_1 will increase.

From equation [8] of the constancy of flow rate it /42
follows that if $F_1 > F_2$, then $v_1 < v_2$. On the other hand, it follows from equation [9] that if $v_1 < v_2$, then $\frac{p_1}{\gamma} > \frac{p_2}{\gamma}$, i.e., in a constricted section the speed increases and the pressure decreases. Again, if $F_2 < F_3$, then $v_2 > v_3$ and $\frac{p_2}{\gamma} < \frac{p_3}{\gamma}$,

i.e., in a widened section the speed decreases and the pressure rises.

2. The Design and Operation of the NCh-3 Water-Jet Fish Pump

The water-jet fish pump (see Fig. 9) consists of an engine-operated centrifugal pump; an ejector pump, consisting of a mixing chamber with a nozzle and an intake hose; a vent; a diffuser, and a water separator. The centrifugal pump delivers, at a pressure of 1.2 to 1.4 atmospheres, water for operations to a

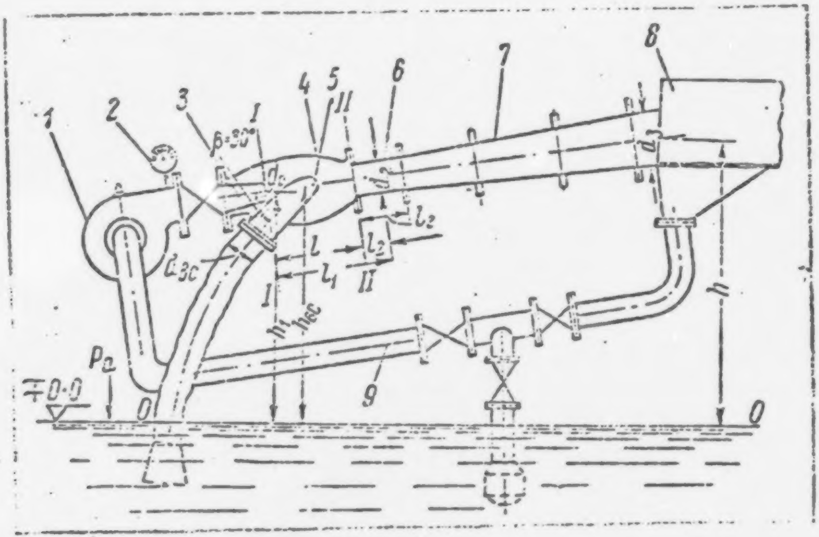


Figure 9 - Diagram of a water-jet fish pump:

1 - centrifugal pump; 2 - pressure gauge; 3 - nozzle for supplying operating water; 4 - mixing chamber; 5 - branch intake pipe with hose and spout; 6 - cylindrical vent; 7 - diffuser; 8 - water separator; 9 - main line for supplying water to centrifugal pump.

conical nozzle introduced into the mixing chamber. The mixing chamber is of cast iron with a cast-on branch intake pipe, to which is attached an intake hose or pipe. On the end of the intake hose or pipe is put a metal head in the form of a bell mouth, which is lowered into the mixture being pumped.

The jet of water in front of the nozzle has a reserve of potential pressure energy. In the nozzle, this energy is converted into kinetic energy, and the jet, emerging from the nozzle with high velocity (16 to 19 metres per second), draws off the surrounding atmosphere and creates a rarefaction (vacuum) in the chamber. Under the effect of the atmospheric pressure, the mixture of fish and water that is being pumped (the operating mixture), which here absorbs part of the kinetic energy of the jet of operating water, passes along the intake hose to the mixing chamber. Under the effect of the kinetic energy the mixture passes to the vent and then to the diffuser. The vent - a segment of cylindrical pipe - ensures that the streams of operating mixture and operating water are thoroughly mixed. In the diffuser, which is a conical expanding pipe, the speed of the stream decreases and the pressure increases, i.e., there occurs a counter transformation of the kinetic energy of the stream to potential energy. Under the action of the pressure, the mixture passes from the diffuser to the stand pipe or to the grating of the water separator. The fish roll off the grating of the water separator onto an elevator, while the water falls into a pan and runs off into a pipe connected to the intake pipe of the centrifugal pump. The circulation of operating water, then, can be established, if desired, in a closed system, which promotes an increase in the efficiency of the fish pump. /43

Among the advantages of a water-jet fish pump should be included the absence of a return valve at the end of the intake hose, owing to which it is comparatively easy to work with it /presumably the hose_7. Moreover, the operation of the fish pump is not disrupted because of the entry of air into the intake hose; this distinguishes the water-jet fish pump from centrifugal fish pumps, which are extremely sensitive to this occurrence.

The water-jet pump can be put into operation even if air is present in the mixing chamber and in the intake pipe. There is no need to prime it /presumably the pump_7 with water prior to the beginning of work. This is extremely important when the water-jet pump is transferring fish, where the rapidity of the work and convenience in maneuvering the unfilled intake pipe represent very important qualities of the transshipping installation.

3. The NCh-3 Fish-Pumping Unit

In Fig. 10 is shown a line diagram of a fish-pumping unit for transshipping a mixture of fish and water from fishing gear and ships' holds.

A centrifugal pump mounted on a wharf supplies water through a starting valve to the water-jet fish pump.

The branch intake pipe of the water-jet pump is provided with a special gasket, owing to which there is no break in the imperviousness of the connection between the mixing chamber and the intake pipe when the latter is raised and lowered. In order to direct the fish properly along the /44 axis of the intake pipe, on the end of the latter there is a conoid nozzle which in addition reduces the resistance accompanying the entry of liquid into the pipe.

From the diffuser nozzle the mixture passes into a [combined] circulating tank and water separator that is provided with a grating. The grating is placed on the level of the diffuser outlet and serves to separate part of the water from the mixture. The water that is separated by the grating comes back along a return pipe through a regulating valve and a hose to the ship in order to maintain a constant concentration of the mixture of water and fish.

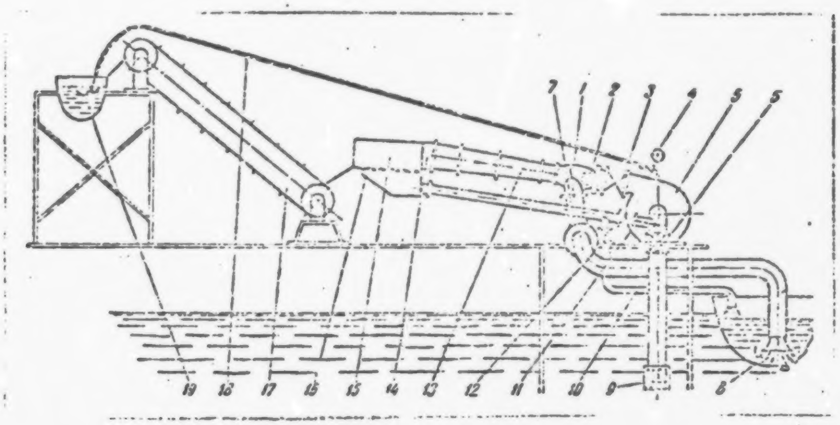


Figure 10 - Line diagram of a water-jet fish pump installation:

1 - water-jet apparatus; 2 - nozzle; 3 - starting valve; 4 - pressure gauge; 5 - centrifugal pump; 6 - valve on intake pipe of centrifugal pump; 7 - gasket on intake pipe of water-jet apparatus; 8 - spout on intake pipe; 9 - shore piece of centrifugal pump; 10 - pipe for return delivery of water to ship; 11 - by-pass

valve; 12 - valve for return delivery of water to ship;
13 - diffuser of water-jet apparatus; 14 - diffuser spout;
15 - [combined] circulating tank and water separator;
16 - water separator grating; 17 - scraper conveyor;
18 - pipe for delivering water to hydraulic conveyer;
19 - hydraulic conveyer.

The fish with the remaining water go out of the circulating tank directly into the hydraulic conveyer or onto the scraper conveyer, with which they are raised to the height of the hydraulic conveyer. In the latter instance the fish are separated from the water when they proceed to the scraper conveyer.

Water is delivered to the hydraulic conveyer by a centrifugal pump (which supplies the fish-pumping installation) through a separate pipe at the rate of 60 cubic metres per hour. The centrifugal pump is fed with pure water from a reservoir with the aid of a pipe and an intake vent through a valve. For the preliminary priming of the centrifugal pump and the intake valve there is a bypass valve which connects them to the return pipe. Before work is ended, there always remains enough water in the circulating tank for the next priming of the centrifugal pump and the vent; hence rapidity and convenience are achieved in the work.

When fishing gear is being unloaded, there is no necessity for the artificial creation of a mixture of fish and water. In this case the bypass valve is used for supplying the centrifugal pump with water from the circulating tank; as a result, energy is economized, since here the centrifugal pump consumes no energy in raising water from the level of the reservoir to the level of the pump axis.

The ship to be unloaded is moored at the wharf. The intake pipe is lowered in such a way that the spout will be buried in the fish. The hose delivering water to the fish is at first arranged so that the water will be fed directly to the spout, thereby creating the required mixture around it.

At the same time that the priming water is delivered, the regulating valve is opened and the fish pump is switched on.

The mixture of fish and water is drawn out of the ship with the intake pipe and is transferred by the fish pump to the water separator and then to an inclined conveyer. Part of the water returns through the grating of the water separator along a pipe to the ship, in this way maintaining the concentration of the mixture of water and fish within the necessary limits. As the fish is being unloaded, the hose for supplying the priming water is moved by a worker to the end of the ship's hold, and the fish is washed from the entire hold in the direction of the intake pipe by the jet of water emerging from the hose. Before the unloading is ended, the valve on the pipe supplying water to the hold is shut off. After all of the water has been pumped from the ship, the fish pump is stopped by closing the starting valve.

4. Calculating the Efficiency of an NCh-3 Fish-Pumping Installation

For a standard calculation of efficiency we have selected the fish pump with the heaviest workload during the fishing season at one of the Kamchatka fishing combines. This pump must ensure the mechanized receiving of no less than 3,000 hundredweight [300,00 kg] of fish in a ten-hour working day. On the heaviest workdays, the processing plant works 16 hours out of 24.

As the practice of many years has shown, a fish-receiving plant cannot work for more than 10 hours a day because of tidal currents, irregularity in the arrival of fish at various times of the day, and so on. The receiving facilities, therefore, should in 10 hours supply enough fish to keep the processing plant busy for 16 hours.

Observations made over several years have shown that the coefficient of use of a fish pump at a fishing combine amounts on the average to no more than 0.5. Consequently, the output of the installation Q_{r1} should come to

$Q_{рл} = \frac{3000}{0.5 \cdot 10} = 600$ hundredweight per hour = 60 tons of fish per hour.

The fish pump operates, drawing in a mixture of fish and water; for purposes of calculation, therefore, its efficiency should be expressed in volumetric units of the mixture that is transferred, referred to a unit of time. /46

$$Q_{вс} = \frac{Q_{рл} \cdot 100}{\gamma \cdot i \cdot 3600}, \qquad (12)$$

where: Q_{vs} is the output per second of the installation in terms of cubic metres of a mixture of fish and water;

Q_{r1} is the hourly fish output in T;

γ is the specific gravity of the fish, which is equal to 1 T/m^3;

i is the average fish content in the mixture that is being drawn in, in percent; for purposes of calculation we assume that i = 20%.

Substituting numerical data, we obtain

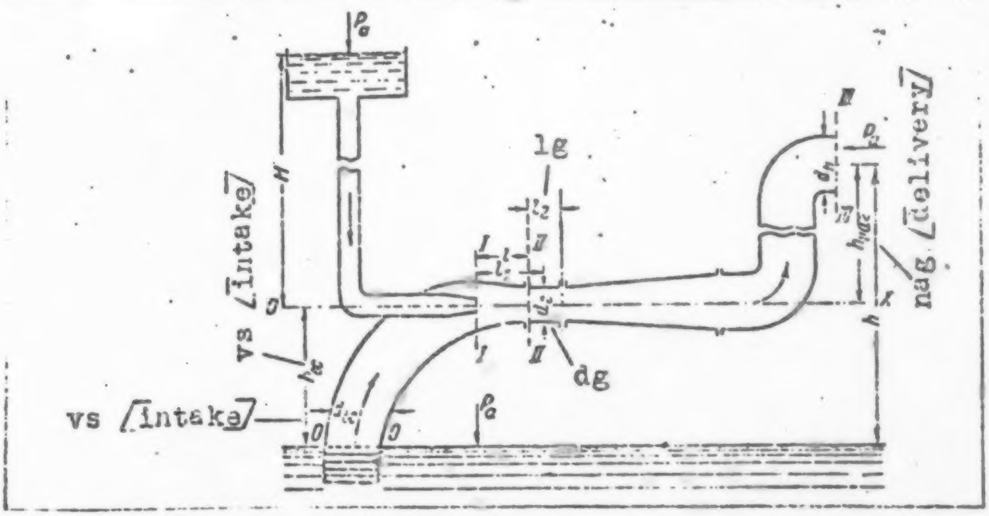
$$Q_{\text{вс}} = \frac{60\cdot 100}{1\cdot 20\cdot 3600} \simeq 0{,}085\ \text{м}^3/\text{сек} = 85\ \text{л/сек}.$$

vs m/sec litres/sec

5. Rating a Water-Jet Fish Pump[1]

Initial data

A water-jet pump (see Fig. 11) used for transferring fish is rated in the same way as a water pump. Practice has shown that when a pump is converted from pumping pure water to pumping a mixture of fish and water, no changes are observed either in efficiency or in energy consumption.



p_a
H
vs [intake]
0
vs
$h_{вс}$
vs [intake]
$d_{вс}$
0
0
p_a
lg
l_2
I
II
l
l_1
d_2
I
II
dg
III
p_2
$d_н$
III
$h_{наг}$
nag [delivery]
h

1

Figure 11 - Rating diagram of the operation of a water-jet fish pump.

---

[1] For more detail on this matter, see the book by Professor P.A. Sviderskii, Pumps for the Fishing and Canning Industries, State Scientific and Technical Publishing House for the Food Industry [Pishchepromizdat], 1943.

The water-jet pump used in a fish-pumping installation /47
differs from an ordinary pump in the angle of connection of its branch intake pipe; in the shape of its mixing chamber and nozzle; in the relative arrangement of its nozzle, vent and branch intake pipe, and in the smooth contours and passageway dimensions of the entire structure, which have been designed for the complete elimination of damage to fish that is being transferred. For water-jet fish pumps some basic dimensions do not always coincide with those that contribute to the highest efficiency.

The density of the mixture of fish and water ($\gamma_{\underline{sm}}$) is taken in a rating as equal to the density of fresh water, i.e., $\gamma_{\underline{c}} = 1$ T/m^3.

The specific gravity of fish varies absolutely depending upon its condition (whether it is alive, has recently died, or has lain for a long time), but to an extent that is so slight that it may be practically disregarded, especially as a fish pump has mainly to transfer live and recently dead fish whose density is equal to $\gamma_p \approx 1$ T/m^3. The specific gravity of live ocean fish is equal to 1.03 to 1.04.

For free passage of the fish, and in order to keep the water moving at a speed which will not permit live fish to resist the current, we select the following (see Fig. 11):

$d_{\underline{vs}}$ = 250 mm is the diameter of the intake pipe,

$d_{\underline{n}}$ = 350 mm is the diameter of the stand pipe;

$d_{\underline{g}}$ = 180 mm is the diameter of the vent for mixed herring and flounder and for pink salmon;

d'_g = 200 mm is the diameter of the vent for chum and coho;

l_g = 500 mm is the length of the vent;

l = 0.457 m is the distance from the end of the nozzle to the beginning of the vent;

l_1 is the distance from the nozzle to the middle of the vent, in metres.

The most important dimension - the vent diameter d_g - cannot be less than 180 mm, since large fish must be admitted. This dimension can be less for herring, but since flounder, which can block up the vent at the time of operation, will be caught together with herring, it is not reduced.

When coho and chum are being transshipped with a fish pump, the vent diameter d'_g should be equal to 200 mm. The other parts of the fish pump remain the same.

The distance l from the end of the nozzle to the beginning of the vent is set at a minimum (475 mm) also so that the most vulnerable part of the fish's body may have free passage. If it is borne in mind that half the length of the vent is actually also included in this distance,

l_1 = 457 + 250 = 707 mm.

We assume that the quantity of mixed fish and water drawn in, Q_{vs}, and the quantity of operating water Q_r delivered through the nozzle by the centrifugal pump, are the same

$$\underset{vs}{Q_{\text{вс}}} = \underset{r}{Q_{\text{р}}} \simeq 0{,}055\ \underset{sec}{\text{м}^3/\text{сек.}}$$

The total flow rate of the liquid passing through the vent comes to /48

$$Q_{\underset{g}{г}} = Q_{\underset{vs}{вс}} + Q_{\underset{r}{р}};\tag{13}$$

$$Q_{\underset{g}{г}} = 0{,}085 + 0{,}085 = 0{,}17 \ \underset{sec}{м^3/сек.}$$

The average velocity v_g of the passage of a mixture in the vent where the diameter d_g = 180 mm will be

$$v_{\underset{g}{г}} = \frac{Q_г}{F_г},\tag{14}$$

where F_g is the area of the vent section;

$$v_{\underset{g}{г}} = \frac{0{,}17\cdot4}{3{,}14\cdot0{,}18^2} = 6{,}7 \ \underset{sec}{м/сек.}$$

Determining the Pressure at the Beginning of the Mixing Chamber

In order to determine the pressure at the beginning of the mixing chamber, we draw up Bernulli's equation for the beginning of the intake pipe (section 0-0) and the beginning of the mixing chamber (section I-I)

$$\frac{v_0^2}{2g} + \frac{p_0}{\gamma} + z_0 = \frac{v_{\overset{vs}{вс}}^2}{2g} + \frac{p_1}{\gamma} + z_1 + \Sigma h_w,\tag{15}$$

where $\sum h_w$ is the sum of the pressure head losses during the movement of the mixture in the intake pipe, in metres of a column of water.

We determine the known values of the components of this equation.

$v_0 = 0$, consequently, $\frac{v_0^2}{2g} = 0$; p_0 is the atmospheric pressure $\cong$ 10 metres of a column of water;

$\underline{z_0} = \underline{h_{vs}} = -2.33$ m;

$\underline{z_1} = 0$ (the axis "0" coincides with the axis of the pump);

$$\underset{vs}{v_{вс}} = \frac{Q_{вс}}{F_{вс}} = \frac{0,065 \cdot 4}{3,14 \cdot 0,25^2} = 1,73\ \underset{sec}{м/сек};$$

then

$$\frac{\overset{vs}{v^2_{вс}}}{2g} = \frac{1,73^2}{2 \cdot 9,81} = 0,153\ м.$$

We shall determine the sum of losses in pressure head by elements.

Losses at the intake

$$\underset{vkh}{h_{w_{вх}}} = \xi_1 \frac{\overset{vs}{v^2_{вс}}}{2g} = 0,1 \frac{1,73^2}{2 \cdot 9,81} = 0,015\ м, \qquad [16$$

where ξ_1 is the coefficient of losses at the intake.

The losses at the elbows of the intake pipe /49

$$\underset{kol\ [elbows]}{h_{w_{кол}}} = \xi_2 \frac{\overset{vs\ [intake]}{v^2_{вс}}}{2g}. \qquad [17]$$

The coefficient of losses at the elbows of the intake conduit ξ_2 is determined from the empirical formula

$$\xi_2 = \frac{\theta}{90^\circ}\left[0,131 + 0,163\left(\frac{D}{R}\right)^{3,5}\right], \qquad [17a]$$

where D = 0.25 m is the diameter of the pipe;

R = 0.5 m is the radius of the curvature of the elbow;

θ is the overall deflection angle of all the elbows of the intake conduit;

$\Theta = 2 \cdot 60 + 90$ (two 60° elbows and one 90° elbow).

$$\xi_2 = \frac{2 \cdot 60 + 90}{90} \left[0,131 + 0,163 \left(\frac{0,25}{0,50} \right)^{3,5} \right] = 0,338 \text{ м}.$$

$$h_{w_{кол}} = 0,338 \frac{1,73^2}{2 \cdot 9,81} = 0,052 \text{ м}.$$

kol [elbows]

Losses along the length of the (steel) intake pipe

$$h_{w_{тр}} = \frac{\lambda L}{d_{вс}} \cdot \frac{v_{вс}^2}{2g}, \qquad [18]$$

tr [pipe] — vs

where: L is the length of the pipe, in metres, equal to 16 m;

λ is the coefficient of resistance in the pipes, depending upon their diameter and roughness; in this case it is equal to 0.02;

d_{vs} is the diameter of the intake pipe.

$$h_{w_{тр}} = \frac{0,02 \cdot 16 \cdot 1,73^2}{0,25 \cdot 2 \cdot 9,81} = 0,196 \text{ м};$$

tr [pipe]

$$\Sigma h_w = 0,015 + 0,052 + 0,196 = 0,263 \text{ м}.$$

Substituting in equation [15] the values found and solving this equation relative to $\frac{p_1}{\gamma}$, we obtain

$$\frac{p_1}{\gamma} = 0 + 10 - 2,33 - 0,158 - 0 - 0,263 = 7,254 \text{ м}.$$

Determining the Speed of the Operating Water

Bernulli's equation is inapplicable for determining the speed v_r of the jet emerging from the nozzle (the operating water), since the flow rate is inconstant in different cross sections of the mixing chamber.

Allowing for losses, however, the energy of the stream remains constant /50
for all of its cross sections. We shall write the expression of the energy of the stream for sections I-I and II-II

$$\gamma \underset{\text{VS}}{Q_{вс}} \frac{v_{вс}^2}{2g} + \gamma \underset{\text{VS}}{Q_{вс}} \frac{p_1}{\gamma} + \gamma \underset{\text{VS}}{Q_{вс}} z_1 + \gamma Q_p \frac{v_p^2}{2g} + \gamma Q_p \frac{p_1}{\gamma} + \gamma Q_p z_1 = \gamma (\underset{\text{VS}}{Q_{вс}} + Q_p) \frac{v_2^2}{2g} + \gamma (\underset{\text{VS}}{Q_{вс}} + Q_p) \frac{p_2}{\gamma} + \gamma (\underset{\text{VS}}{Q_{вс}} + Q_p) z_2 + \Delta \underset{\text{sm}}{E_{см}} \qquad [19]$$

where $\gamma Q_{вс}$ — is the mass flow rate of the mixture drawn in, in tons per second;

γQ_p — is the mass flow rate of operating water in tons per second;

v_p — is the velocity of the operating water;

$\Delta E_{см}$ — is the loss of energy when the two streams are mixed.

In conformity with the conditions that have been assumed, $z_1 = z_2 = 0$ and [illegible] = 1.

Substituting in equation [19] the values found previously and solving it relative to v_r^2, we have

$$0{,}085 \frac{1{,}7^2}{2 \cdot 9{,}81} + 2 \cdot 0{,}085 \cdot 7{,}254 + 0{,}085 \frac{v_p^2}{2 \cdot 9{,}81} = 0{,}17 \frac{6{,}7^2}{2 \cdot 9{,}81} + 0{,}17 p_2 + \Delta E_{см}; \text{ отсюда}$$

$$0{,}00433 v_p^2 = 0{,}17 p_2 + \Delta E_{см} - 0{,}857. \qquad [20]$$

Here, apart from the value of v_r, p_2 and E_{cm} are still unknown. In order to determine p_2 we draw up Bernulli's equation for sections II-II and III-III.

$$\frac{v_2^2}{2g} + \frac{p_2}{\gamma} + z_2 = \frac{v_3^2}{2g} + \frac{p_3}{\gamma} + z_3 + \Sigma h_w, \qquad [21]$$

$$v_3 = \frac{Q_3}{F_3}; \; Q_3 = Q_2 = Q_p + Q_{\text{вс}};$$

vs

$$v_3 = \frac{(Q_p + Q_{\text{вс}})\,4}{\pi \cdot d_3^2}.$$

The speed at which the mixture emerges from the diffuser

$$v_3 = \frac{0{,}17 \cdot 4}{3{,}14 \cdot 0{,}35^2} = 1{,}77 \text{ м/сек.}$$

sec

metres per second.

The pressure in the section III-III is equal to the pressure of /51

of the atmosphere

$$\frac{p_3}{\gamma} = \frac{p_a}{\gamma} \cong 10 \text{ м};$$

$$z_2 = 0; \; z_3 = h_{\text{нап}} = 0{,}67 \text{ м.}$$

nag [delivery/pressure]

For determining $\sum h_{\text{п}}$ we assume that the basic energy losses in the diffuser occur where the stream widens, and that the others may be disregarded. Then

$$h_{\text{п диф}} = \xi_{\text{диф}} \frac{v_2^2}{2g} = 0{,}25 \cdot \frac{6{,}7^2}{2 \cdot 9{,}81} = 0{,}574 \text{ м.}$$

dif [diffuser]

When we have substituted in equation [21] the data obtained and solved this equation relative to $\frac{P_2}{\gamma}$, we get

$$\frac{p_2}{\gamma} = \frac{1{,}77^2}{2 \cdot 9{,}81} + 10 + 0{,}67 + 0{,}574 - \frac{6{,}7^2}{2 \cdot 9{,}81} = 9{,}113 \text{ м.}$$

We shall now proceed to a determination of energy losses in the chamber from the mixing of the two streams. For determining the sum of the losses in the mixing chamber we shall use Bergeron's hypothesis, in conformity with which the ΔE_{cm} of the chamber is calculated from the formula

[mixture]

$$\Delta E_{\text{см}} = \gamma Q_p \frac{(v_p - v_2)^2}{2g} + \gamma Q_{\text{вс}} \frac{(v_{\text{вс}} - v_2)^2}{2g}; \qquad [22]$$

$$\Delta E_{\text{см}} = 0{,}085 \frac{v_p^2 - 2v_p v_2 + v_2^2}{2 \cdot 9{,}81} + 0{,}085 \frac{(1{,}73 - 6{,}7)^2}{2 \cdot 9{,}81};$$

$$\Delta E_{\text{см}} = 0{,}00433\, v_p^2 - 0{,}00866 \cdot 6{,}7\, v_p + 0{,}00433 \cdot 6{,}7^2 +$$

$$+ 0{,}00433 \cdot 24{,}7 = 0{,}00433\, v_p^2 - 0{,}0578\, v_p + 0{,}303.$$

When we have substituted in equation [20] the values that we have found, $\frac{r_2}{\gamma}$ and ΔE_{cm}, and when we have solved this equation relative to v_r, we get

$$0{,}00433\ v_p^2 = 0{,}17 \cdot 9{,}113 + -0{,}00433\ v_p^2 - 0{,}0578\ v_p + 0{,}303 - 0{,}857,$$

whence

$$0{,}0578\ v_p = 0{,}992;\quad v_p = \frac{0{,}992}{0{,}0578} = 17{,}1\ \text{м/сек.}$$

sec

Checking Safety Conditions for Fish in a Water-Jet Apparatus

Within a water-jet apparatus fish can be injured either by striking the wall of the apparatus or by being struck by the jet of operating water flowing from the nozzle. Fish can be damaged by striking the wall only if the former is moving at considerable speed. It is evident that for each fish there exists some kind of maximum, i.e., critical, speed, upon exceeding which the fish can be smashed when it strikes the wall (for more detail on this matter, see Chapter IV). /52

A.V. Terent'ev has derived the value of the critical speed

$$s_{kr}\ [\text{critical}]\ c_{кр} = \sqrt{\frac{T_{кр} \cdot 2g}{G_p}}, \qquad [23$$

where: T_{kr} is the work of disintegrating the fish, in kilogram-metres;

G_r is the weight of a fish specimen in kilograms;

$g = 9.81\ m/sec^2$.

Evidently, in order that fish may not be crushed within the water-jet apparatus it is sufficient to observe the following condition:

$$v_{\kappa} < c_{\kappa p}, \quad \text{kr} \qquad (24)$$

where $\underline{v_n}$ is the speed in any characteristic cross section.

Making use of the data in Table 1, we shall calculate the critical speed and compare it with speeds in characteristic cross sections (since we have no data on the value of $\underline{T_{kr}}$ for fish of the salmon family, we shall take this value for pike-perch as resembling the salmonids fairly closely in shape)

$$\underset{\text{kr}}{c_{\kappa p}} = \sqrt{\frac{12,85\cdot 2\cdot 9,81}{1,82}} = 11,8 \text{ м/сек.} \quad \text{sec}$$

The speed of the stream in the intake pipe according to the value calculated previously amounts to $\underline{v_{vs}}$ = 1.73 metres per second.
5.7 ft/sec.

The speed at the entrance to the mixing chamber will amount, on the average in a cross section, to

$$\text{kam } (\text{chamber}) \quad v_{\kappa a m} = \frac{(Q_{\text{вс}} + Q_p)\,4}{\pi d^2_{\kappa a m}} = \frac{0,17\cdot 4}{3,14\cdot 0,294^2} = 2,5 \text{ м/сек.} \quad \text{sec}$$

metres per second.

It must be noted that the value of 2.5 metres per second represents the average speed through a cross section; in the centre of the cross section the speed will be much higher.

According to values calculated previously, the speed in a vent with a diameter of 180 mm amounts to $v_g = 6.7$ metres per second, while the speed at the outlet of the diffuser $v_3 = 1.77$ metres per second.

Thus the speed of the stream in all characteristic cross sections within the water-jet apparatus is less than the critical speed.

Let us examine the effect of the speed of the operating water v_r. At the nozzle outlet $v_r = 17.1$ m/sec $> s_{kr}$. Upon further movement, the speed of the operating water drops in proportion as the latter is mixed with the liquid that is drawn in, declining in the vent to an overall speed, $v_g = 6.7$ metres per second, which is the average through the cross section of the vent.

It may be assumed that in the region in which the fish enters /53
the mixing chamber the speed of the jet of operating water will be close to an average value between $v_r = 17.1$ and $v_g = 6.7$ metres per second, i.e.,

$$\frac{17{,}1 + 6{,}7}{2} = 12{,}35 \text{ м/сек.}$$ —— metres per second

At the same time, the speed of movement of the fish $v_{vs} = 1.73$ metres per second. The relative speed of the operating water will be 12.35-1.73 = 10.52 metres per second, i.e., lower than the critical speed. Thus the safety of the fish is ensured when it comes into contact with the jet of operating water, all the more in that the speed of the jet of operating liquid will evidently be less because of losses on friction and the spreading of the jet.

All of the foregoing reasoning can evidently be used to explain why each fish has its own limit, discovered on a practical basis, of the height to which it can be drawn in when it is pumped by a water-jet fish pump.

In order to increase the height to which fish are drawn in, it is necessary to increase the speed of the jet of operating liquid flowing from the nozzle. Moreover, at the same time, the speeds in the centre of the middle cross section of the mixing chamber very rapidly become greater than the critical speeds, which immediately leads to damage to the fish. It has in fact been observed that the quantity of damaged fish, when the latter is transshipped with a water-jet fish pump, increases noticeably if the height to which the fish is drawn in exceeds the maximum permissible value for fish of a given species.

Determining Other Values and Efficiency

The diameter of the nozzle is determined from the equation

$$Q_p = \mu v_p F_p = \mu v_p \frac{\pi d_p^2}{4}, \qquad [25]$$

where: μ is the coefficient of flow rate for a conical convergent nozzle, equal to 0.94 to 0.95;

$$d_p = \sqrt{\frac{4 Q_p}{\mu \pi v_p}}; \qquad [25a]$$

$$d_p = \sqrt{\frac{4 \cdot 0{,}035}{0{,}94 \cdot 3{,}14 \cdot 17{,}1}} = 0{,}082 \text{ м}.$$

The required pressure head of operating water N is calculated from Toricelli's formula, clarified by Bernulli,

$$v_p = \mu\sqrt{2g\left(H + \frac{p_2 - p_1}{\gamma}\right)},$$

whence /54

$$H = \frac{v_p^2}{\mu 2g} - \frac{p_2 - p_1}{\gamma}; \qquad (26)$$

$$H = \frac{17,1^2}{0,94^2 \cdot 2 \cdot 9,81} - (10 - 7,254) = 14 \text{ м}.$$

The power consumption of a centrifugal pump is determined from the formula

$$N = \frac{\gamma Q_p H'}{75\eta}, \qquad (27)$$

where: Q_p is the flow rate in litres per second, equal to 85 litres/sec;

H' is the full height of the pressure head, allowing for the intake height and losses in the intake pipe and the diffuser;

η is the efficiency of the centrifugal pump.

$$N = \frac{1 \cdot 85\,(14,0 + 2,33 + 0,283 + 0,574)}{75 \cdot 0,5} = 39 \overset{hp}{\text{л. с.}} = \qquad \text{kilowatts.}$$

$$= 0,736 \cdot 39 \simeq 28 \text{ квт}.$$

We determine the efficiency of a water-jet fish pump, when it is working with pure water, as the ratio of the work expended to the useful work obtained.

For convenience in comparing the results of theoretical calculations with the results of experimental research, the efficiency for water is calculated without allowing for the hydraulic resistances of the water-jet pump itself, which is reflected only to a very limited extent in the final value /1/.

vs [intake]

vod [water] $$\eta_{\text{вод}} = \frac{\gamma Q_{\text{вс}}}{\gamma Q_{\text{р}}} \cdot \frac{h}{H},$$ [28

where h = 3 metres is the full height to which the mixture is raised by the pump;

vod [water] $$\eta_{\text{вод}} = \frac{1 \cdot 0{,}085}{1 \cdot 0{,}085} \cdot \frac{3}{14} \cong 0{,}21.$$

The efficiency of a fish pump, calculated in relation to the work expended in raising the fish (the efficiency for fish is ryb (fish)) is a variable that depends upon the fish content of the water that is being drawn in. This value does not characterize the fish pump as a machine and depends upon the organization of the work and the qualifications of the attendants

ryb [fish] $$\eta_{\text{рыб}} = \eta_{\text{вод}}\, i;$$ vod [water] [28а

$$\eta_{\text{рыб}} = \frac{\gamma Q_{\text{вс}}}{\gamma Q_{\text{р}}} \cdot \frac{h}{H} \cdot i,$$ [28б

where i is the fish content in the mixture that is drawn in (the concentration).

As a result of a number of specially arranged experimental studies /55 it has been discovered that for the normal operation of industrial installations the pressure of the operating water in front of the nozzle should be somewhat less than that which has been calculated. This can be explained only by the fact that when calculations were made, energy loss values were assumed that were too high. The greatest energy loss, in whose calculation a considerable error could have been made, is that in the chamber when two streams are mixed: the low-pressure stream of the mixture of fish and water being drawn in, and the high-pressure operating water flowing from the nozzle in the form of a jet.

Of value for reducing actual losses of energy is the fact that the jet of operating water from the nozzle, passing through the centre of the vent, moves in that part of the liquid which has the greatest velocity. The speed of movement of individual small jets of liquid in the conduit is irregular: it decreases from the centre towards the walls. Therefore the value of the losses from the mixing of the streams, calculated from the difference in the velocity of the operating water and the average speed of movement of the mixture in the vent, is exaggerated.

Actually, the jet of operating water, passing through the vent, does not reduce its [the jet's] speed to the value of the average speed with which the mixture passes through, but rather continues to move for some time with a speed greater than the average speed in the diffuser. This is confirmed by the results of experimental observations. Therefore the correction factor φ_{κ} should be introduced into the formula for calculating losses of energy when streams mix. According to preliminary research, the value φ_{κ} = 0.75 to 0.8. Then the expression of the energy loss from the mixing of the two streams will appear as

$$\underset{\text{mixture chamber}}{\Delta E_{\text{см камеры}}} = \varphi_{\kappa}\left[\gamma Q_{p}\underset{\varepsilon}{\frac{(v_p - v_z)^2}{2g}} + \gamma \underset{\text{vs}}{Q_{вс}}\frac{(\overset{\text{vs /intake/}}{v_{вс}} - v_z)^2}{2g}\right]. \qquad [29]$$

There also exist other methods of making calculations for water-jet pumps (see Table 6).

When the computed basic values for water-jet pumps are compared, it may be seen that the values nearest to practical results are given by the method of calculating according to the principle of the free spreading of the jet[1], which is being more and more widely applied in technology.

A considerable discrepancy with practical data occurs only in the values of the diameters of the vent and the nozzle. This is explained by the specificity of making calculations for water-jet pumps that transfer a mixture of fish and water. Ordinarily, when calculations are made for water-jet pumps, an attempt is made to obtain the best efficiency. We, on the other hand, when making calculations for a water-jet pump, must adopt those constructional dimensions at which fish will pass through /56
the pump without damage.

The method of making calculations according to the principle of the mixing of the streams gives results close to those obtained in practice only on condition that the correction coefficient $\varphi_{\kappa} = 0.75$ to 0.8 is introduced into the losses occurring when the streams are mixed in the mixing chamber.

It must be noted that the theoretical calculations pertaining to the main constructional elements, attached to the calculations for specialized water-jet pumps pumping fish, help to determine the optimum

---

[1] P.A. Sviderskii, Pumps for the Fish and Canning Industries. Pishchepromizdat (State Scientific and Technical Publishing House for the Food Industry), 1943.

Table 6

The Results of Water-Jet Pump Calculations

Made Using Different Methods

Method of Calculation	Basic computed values							
	Speed in vent v_E, in m/sec	Speed of operating water at nozzle outlet v_T, in m/sec	Pressure of operating water in front of nozzle $\underline{N}$, in metres of a column of water	Diameter of nozzle d_T, in mm	Diameter of vent d_E, in mm	Distance from end of nozzle to beginning of vent, in mm	Efficiency	Power $\underline{N}$ in hp
Mixing of streams, allowing for actual speed..............	6,7	17,1	14	82	180	—	0,21	38
Mixing of streams, allowing for theoretically required speed..............	9,88	17,7	15	81	148	—	0,20	40
Mixing of streams, allowing for correction factor for losses in mixing chamber 0.75 to 0.8.........	9,88	16,5	12,7	83	146	—	0,24	35
Free spreading of jet[1]	10,15	14,4	9,5	87	148	627	0,32	26
Average data from experimental observations on working fish pumps.........	6,7	16,1	10,7	82	180	457	0,28	31

---

[1] Spreading can occur in any area of the 500-mm-long cylindrical insertion piece of the vent. Actually, spreading can occur in the interval from 457 to 957 mm.

dimensions of the elements that make it possible to obtain the highest efficiency value.

6. Experimental Research /57

Experiments have been set up in order to improve the efficiency of the water-jet pump, and as a result of observations of the operation of a fish pump, certain changes have been introduced into its design.

Special lugs and grooves were made on the mixing chamber and the nozzle, as well as on the vent and the diffuser, for centering these components precisely and keeping them in strict coaxial alignment. Optimum dimensions for the vent and nozzle, as well as an optimum distance from the nozzle to the beginning of the vent, were selected. The inner surfaces of the mixing chamber, the vent and the diffuser were puttied and painted with oil paint. The optimum angle of conicity of the diffuser, equal to 6°, was established, the spout of the diffuser was lengthened to 1.5 m (its length was previously 0.35 m), and the elbow was removed to an angle of 90° from the diffuser spout.

After these improvements in the design of the water-jet pump, its efficiency rose from 0.17 to 0.28.

When the fish pump was mounted on a ship for work as a floating unit in an open roadstead at sea, the necessity arose for creating a closed diffuser with an internal water separator grating. A diffuser of this type in a delivery conduit created pressure sufficient to pump a mixture of fish and water for a considerable distance (several hundred metres).

Pressure may also be created in a delivery conduit by raising a combination open water separator and tank to a height of 3 metres, but this is possible only in stationary installations. A tank of water with pipes, installed on a ship and raised to a height of 3 metres above it, would change the position of the metacentre to such an extent that a ship with such an installation could easily capsize, especially in a rough sea.

Where the diffuser is closed, the entire unit may be installed in the hold and thus increase the vessel's stability.

In outward appearance there is no difference between the closed diffuser and the ordinary diffuser welded to the spout (see Fig. 12), but its end is closed with a flange through which a tube 250 mm in diameter is admitted. The end of the pipe rests against the walls of the diffuser cone at the point where its diameter is 250 mm plus the double thickness of the pipe wall.

Three hundred openings 22 mm in diameter have been drilled in the walls of the inner pipe for separating surplus water from the mixture.

A space into which the water is discharged is formed between the walls of the grate pipe and the diffuser. The water is removed from this space with a connecting outlet pipe back into the centrifugal pump (when fishing gear is being unloaded) or into the ship that is being unloaded in order to maintain the necessary concentration of the mixture of fish and water.

The returning of surplus water to the centrifugal pump when fishing gear is being unloaded yields a considerable saving of energy. In this case there is no need to draw in water from over the side: it comes /58 from the diffuser under pressure.

The diversion of surplus water makes it possible to decrease the diameter of the delivery conduit. If the entire mixture had to be conveyed, in order to decrease losses on friction the speed of movement of the mixture in the pipeline would have to be decreased, i.e., the diameter of the pipeline would have to be increased.

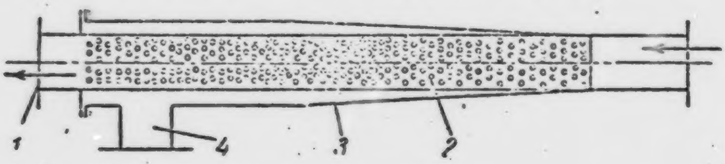


Figure 12 – Closed diffuser:

1. delivery pipe (d = 250 mm); 2. grate pipe; 3. diffuser;
4. branch pipe for diverting water (d = 250 mm).

As trials demonstrated, the qualities of a closed diffuser corresponded fully with those that had been assumed. Moreover, the use of this diffuser caused the efficiency of the fish pump to rise to 0.296, and the limit of the height to which the fish could be pumped without damage rose to 3.2 m.

7. Installation and Operation of a Water-Jet Fish Pump

When a water-jet pump is installed (see Fig. 13) care should be taken that the nozzle 17 consists of two parts: the connecting pipe 15 and the nozzle itself, inserted into the next part along the path of the water – the mixing chamber 13. On the connecting pipe is installed the water pressure gauge 16, graduated up to 3 atmospheres and indicating the pressure of the water fed by the centrifugal pump 3 into the nozzle 17 of the fish pump.

The mixing chamber 13 is made of cast iron; it is very clean and is painted inside. Through it passes the fish drawn through the intake pipe 26 and the connecting pipe of the chamber; this latter pipe has been cast as a single unit with the chamber at an angle of 30°.

On the chamber is mounted a vacuum gauge 14 graduated to 760 mm of a mercury column, showing the degree of rarefaction in the mixing chamber.

The vent 12 is made of cast iron finished inside.

The diffuser 11 and the spout 10 are of smooth welded construction and painted inside. The fish also pass through them. The spout of the diffuser 10 is inserted into the circulation tank 9 through a previously prepared opening. After all pipelines have been assembled, the spout is caulked or welded in the opening so that water will not spill out of the circulating tank 9.

The centrifugal pump 3, the reducer and the engine 2 represent auxiliary mechanisms of the installation. Reducers can differ for various types of centrifugal pumps and engines. Fish does not pass through the auxiliary mechanisms; therefore they can be of the most diverse types and power ranges, as long as they deliver 420 m^3 of water per hour at a pressure of 1.4 atmospheres; this is necessary for the operation of the fish pump. The centrifugal pumps produced by the Petropalovsk Shipyard have 1,500 rpm. If a source powerful enough to deliver 420 m^3 of water per hour at a pressure of 1.4 atmospheres (a water supply line or a waterfall) is locally available, the fish pump may be put into operation from this source, and none of the above auxiliary mechanisms will be required. /59

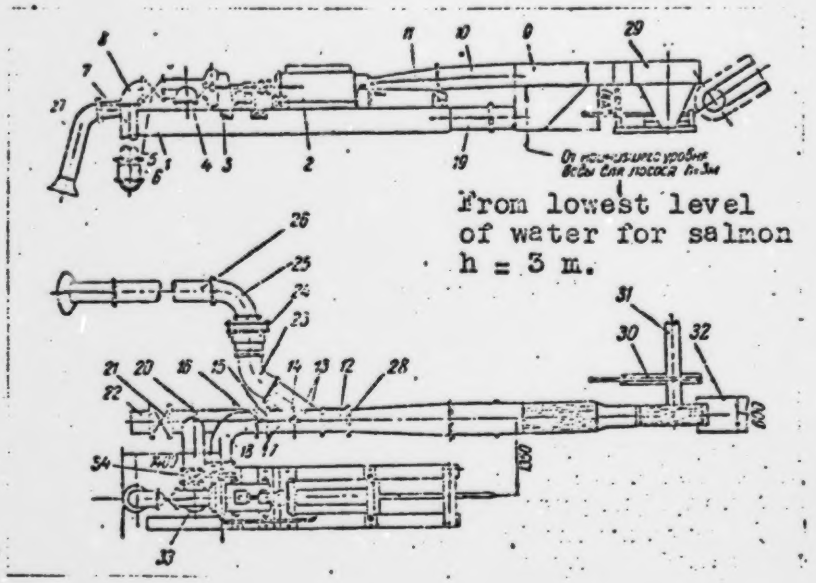

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
From lowest level
of water for salmon
h = 3 m.

Figure 13 - Shore installation of water-jet fish pump

1 - fish pump frame; 2 - engine; 3 - centrifugal pump; 4 - intake T-pipe of fish pump; 5 - valve on intake pipe of centrifugal pump; 6 - valve of centrifugal pump; 7 - pipe; 8 - elbow; 9 - circulation tank; 10 - diffuser spout; 11 - diffuser; 12 - vent; 13 - mixing chamber; 14 - vacuum gauge; 15 - connecting pipe; 16 - pressure gauge; 17 - nozzle; 18 - pressure elbow; 19 - pipe for return delivery of water; 20 - bypass T-pipe; 21 and 22 - valve and branch pipe for flushing ships; 23 - elbow of fish-pump intake pipe; 24 - stuffing box; 25 - elbow; 26 - intake pipe; 27 - spout; 28 - gasket; 29 - water separator; 30 - shut-off device for water; 31 - hose for diverting surplus water; 32 - scraper conveyer; 33 - starting valve; 34 - bypass valve.

Either a smooth, rubberized hose 250 mm in diameter with a steel spiral inside, or a steel thin-walled tube of the same internal diameter can be used as an intake pipe.

In the latter case it is necessary to install a special /60 stuffing box at the point where the intake pipe is connected to the mixing chamber. If the fish pump is manufactured with a steel intake pipe, the stuffing box is included in the set of parts supplied by the manufacturing plant.

The weight of the installation without its engine is approximately 2 tons. Its weight when it is operational, with its pipes, tank and water separator filled with water, is 3 tons. The weight of a filled intake pipe (normal length) is 285 kg. The weight of the movable part of the intake pipe without water is 80 kg.

Installation of the fish pump (see Fig. 13) should begin with the preliminary laying out and assembling of the auxiliary mechanisms: the centrifugal pump, the reducer and the engine, which are installed on the frame 1 of the fish pump.

The frame, with the auxiliary mechanisms fastened on it, is installed and secured in such a way that it will subsequently be convenient to work with the valves of the pipelines and with the intake pipe 26 or with the intake hoses. It is better to work with the intake pipe 26, but it must be remembered that it can turn only in one plane.

The axis of the fish pump should rise to the circulation tank 9 at an angle of 6 to 12°. The required angle of elevation is secured by shifting the openings on the flange of the pressure elbow 18, which is connected to the centrifugal pump. Since extra holes have been drilled in the base of the centrifugal pump, the latter's helix can also be turned through a certain angle if operating conditions require it.

The length of the intake pipe 26 can be changed by combining branch pipes depending upon local conditions. Branch pipes are supplied by the factory together with the unit; the total length of all four such pipes is 10.2 m.

If the length of the above pipes proves to be insufficient for operating conditions, the pipe 26 can be lengthened either by preparing new branch pipes or by lengthening (by welding in inserts) the pipes that have been supplied.

The main intake line 7 of the centrifugal pump is installed so that the pump can receive water from a reservoir with the aid of the valve 6. The valve 6 must be enclosed in order that fish and foreign objects will under no circumstances get into the valve or the centrifugal pump. The water fed by the centrifugal pump is used only as a carrier of energy for the work of the water-jet pump.

The flanges of the fish pump are connected with 5/8" bolts on cardboard [sic] washers. It is desirable to use rubber gaskets for connections with the intake T-pipe 4, since occasionally during work the T-pipe has to be removed in order to inspect the interior of the centrifugal pump and to clear it of objects that have accidentally fallen in and gotten stuck in the blades of the operating wheel.

When installation is being carried out, it should /61 be made certain that the centering lugs of the nozzle, the mixing chamber and the vent enter the corresponding grooves on the dual flanges precisely.

When the intake pipe is assembled, it should be made sure that the outer finished edges of the flanges coincide precisely; otherwise a projection in the shape of a crescent will result inside, which will cause damage to the fish. If the edges of the openings are sharp during processing, it is better to smooth them.

The finished cast iron pipe entering the stuffing box 24 should not, when it swings, abut with its threaded end against an unthreaded part. Before it is connected it should be unscrewed 3/4 of a turn and only after this joined to the remaining part. The elbow 23, with twelve holes in its flange and specially placed at an angle of 60°, serves to align the stuffing box correctly in a horizontal position.

A position should also be selected for the spout 27 of the intake hose in which it /the spout/ will work the most efficiently depending upon local conditions. Thus, for example, when fish is unloaded from ships it may be installed mounted with its bell mouth down, and when fish is being pumped from a drag seine, it can be mounted with its mouth in the direction of the current.

When a fish pump is installed for unloading herring and pink salmon, a vent 180 mm in diameter is installed for herring. The vents are supplied by the manufacturing plant. If the dimensions of the fish (pink salmon and sockeye salmon) permit, operations may be carried out all of the time with a 180-mm vent, with which the fish pump works better. A vent 200 mm in diameter is installed for unloading coho and chum.

If the place where the fish is processed is located at some distance from the fish pump, the fish can be conveyed to such an area along the trough of a hydraulic conveyer, since the fish pump delivers fish and water together. The trough is set at a standard incline (0.005 to 0.01) in the direction of movement. The fish pump can raise herring 2.7 m, and pink salmon, chum and coho 3.2 m, above the level of a river.

If we assume that the shore rises an average of 1.5 m above the level of the river, the reserve of 1 to 1.5 m can be used for conveying horizontally for 100 to 150 m.

The dimensions of the trough should correspond to the outgoing cross section of the circulation tank.

If the fish has to be lifted to a considerable height, the scraper conveyer 32 is installed after the fish pump.

In order to remove a large quantity of water from the fish prior to its entering the scraper conveyer, between the circulation tank 9 and the conveyer 32 is installed the water separator 29, which consists of a trough with a latticed bottom. The lattice is prepared from wooden strips measuring 1.5 x 2.5 cm stood edgewise at intervals of 1.5 cm. For herring, the interval is decreased to 1 cm. The same kind of lattice is made in the circulation tank 9.

Under the latticed bottom should be an airtight pan with a drainpipe 250 mm in diameter. The canvas hose 31 is ∠62 put on the branch pipe in order to draw off excess water. The quantity of water that is drawn off is regulated by the shutoff device 30. Part of the water is left in order to carry the fish out to the conveyer belt 32. The disposal of the water is regulated manually.

The centrifugal pump 3 supplies the hydraulic conveyer with water. When the pump 3 is manufactured, an opening of suitable diameter that is closed with a plug, is cut in its casing.

When water must be withdrawn into the hydraulic conveyer, the plug is removed and an adapter and valve are screwed into the opening.

Water for cooling the motor is taken from the centrifugal pump through a special valve. Since the centrifugal pump 3, which is manufactured by the Petropavlovsk Shipyard, has a counterclockwise rotation, it has to be set in motion from the forward end of the shaft of a ZIS-5 engine. It is with this purpose that the projection of the forward lid of the crankcase is planed off, and that a smoothly engaging half clutch[*] is installed on a key and two locking devices on the projecting forward end of the shaft; this half clutch is then connected to the half clutch of the pump with a rubber disc.

The ZIS-5 engine is installed without a gear box and without a clutch. In a recess of the flywheel, where the clutch cylinder bearing is ordinarily located, a left-hand thread is cut and a left-hand ratchet is screwed in for turning on the engine. Thus the centrifugal pump is rotated counterclockwise by the ZIS-5 motor.

Grooved wooden or metal blocks are prepared under the forward part of the crankcase and under the feet of the engine for reinforcement of the engine itself. The forward part of the engine is fastened with a metal cleat applied to the platform where the fan is usually installed; the rear part is fastened with bolts passed through the feet and the grooved blocks into a bed frame.

---

[*] Translator's note. A suggested rendition of the Russian *polumufta myagkogo stsepleniya*, for which no other suitable equivalent is available.

If there is approximately 20% fish in the water that is drawn in, the fish pump will deliver about 600 centners [60,000 kg] of fish per hour. If a fish concentration of about 30% is arranged, the fish pump, with the same engine and the same fuel consumption, will deliver fish at the rate of about 1,000 centners [100,000 kg] of fish per hour. If the concentration is set at 1%, i.e., if there will be only 1 kg of fish per 100 kg of water, the fish pump, with the same engine and the same fuel consumption, will be able to deliver fish at the rate of only 36 centners [3,600 kg] per hour.

The efficiency of a fish pump, then, depends upon the concentration of the mixture that it is transshipping The normal concentration of fish in a mixture is 20%, and the maximum permissible concentration is 30%; at concentrations higher than this, the fish can be damaged when it passes through the fish pump. In a performance rating the efficiency of a fish pump is indicated for continuous operation.

If a water-jet fish pump delivers more fish than is warranted by production conditions, its efficiency may be decreased by throttling the starting valve 33. Work, however, will be more economical from the viewpoint of fuel consumption if the centrifugal pump is periodically turned off. /63

If the periods for which the pump is switched off last for more than 15 or 20 minutes, the engine, too, is stopped.

If the unit is intended for unloading ships, an elevating device must be installed for raising and lowering the intake pipe 26, and a canvas hose 250 mm in diameter and 3 to 5 m long must be put on the branch pipe 22. The hose is used for flooding the hold of a ship with water in order to create a fish-and-water mixture in this area. [Please ignore space; text is continued on next page.]

Starting and Stopping the Fish Pump

When the unit is not working, all of its valves should be closed and the gears of the reductor disengaged. The motor is prepared in the usual way: the oil level is checked in the motor and the transmission, then the carburetor is warmed up, if the weather is cold, and the engine is started and is thoroughly warmed. After the engine has been checked, the pump is primed. If there is no water in the tank 9, the centrifugal pump is flooded manually through a plug [hole] located above the volute. If possible, the circulation tank is flooded with water from the water supply line and, when the bypass valve 34 and the plug of the volute have been opened, the pump is primed.

In both cases the valve 5 of the intake pipe should first be opened in order that the intake valve may be primed at the same time that the centrifugal pump is primed. When priming has been completed (when water appears in the plug [hole] the bypass valve 34 is shut off, and the plug is put in place. If there is water in the tank 9, the valve 34 and plug are opened and the pump is primed.

When it has been made certain that the intake hose has been lowered into the mixture of fish and water, the fish pump is started. For this purpose, the starting valve 33 must be opened four or five turns until the pressure gauge 16 shows a pressure of 0.1 to 0.15 atmospheres, after which there is a wait of 3 to 4 seconds. At this time, the needle of the vacuum gauge 14 should move and show from 10 to 50 mm of rarefaction. After this the valve 33 may quickly be opened completely.

In order to facilitate the opening of the valve, the number of revolutions of the engine may at first be decreased with the manual gas control lever; the number of revolutions may be increased as the valve 33 is opened.

If, after the valve has been opened four or five turns and there has been a pause of three or four seconds, no vacuum appears, the valve must be opened further at the rate of one turn every two or three seconds until a vacuum appears in the mixing chamber or there is water in the diffuser. If the water pours quietly out of the diffuser into the circulation tank 9, the valve 33 may be opened fully and the vacuum gauge checked. If, on the other hand, the water escapes from the diffuser in a powerful jet, the valve 33 must be shut off immediately and the starting begun again with more care: the valve should be opened and a pause made of six or seven seconds after the valve has been opened four or five turns.

After the needle of the vacuum gauge has moved, the vacuum in the mixing chamber and the pressure at the nozzle should increase as the starting valve 33 is opened. The fish pump operates normally when there is a pressure of 1.2 to 1.4 atmospheres at the nozzle and a vacuum of 160 to 200 mm in the mixing chamber. Pressure is indicated by the pressure gauge 16 /64 mounted on the nozzle, and vacuum, by the vacuum gauge 14 installed on the mixing chamber 13. When the pressure gauge goes out of order, it must be replaced by another.

During normal operation, the water from the spout 10 of the diffuser runs out quietly into the circulation tank 9, filling the entire cross section of the spout outlet. The rate of operation of the fish pump may be judged by the size of the eddy forming at the bell mouth of the intake hose. If the eddy for one reason or another is difficult to discern, the intake hose may be raised a little until the opening is partially revealed. Here, if only the fish pump is operating properly, the air will be sucked into the hose with a snort.

As pumping-out operations proceed, the eddy will increase and less fish will enter. In order to prevent this occurrence, the canvas hose must be promptly shifted further from the spout in order that the effluent stream may carry the fish in the direction of the intake pipe. By means of further shifting of the canvas hose all of the fish may be washed even from the most remote corners of a *kungas*[*] and directed to the intake spout 27.

It is essential that the cargo hold of the ship be equipped with a *poel*[**], otherwise fish will lie between the ribs and then manual work will have to be used for unloading.

---

[*] See *Translator's note*, p 19.

[**] *Translator's note.* No suitable equivalent is available for this term. The context, however, both in this paragraph and below, suggests a type of flooring.

If for one reason or another there is no water in the tank 9 before work begins, the tank must be filled. For this purpose, the pump is started with the intake pipe raised, the starting valve is opened five or six turns, and a jet of water begins to gush from the diffuser. The valve is opened far enough that the jet will gush no further than the circulation tank 9 and that water will remain in it. After the tank has been filled, the starting valve is throttled, and subsequent operations are such as has been described above.

In order to decrease the number of shifts of the canvas hose it is better to let the intake pipe down lower towards the stern or bow bulkhead in such a way that it will be possible only to move the hose away from the bell mouth, and not throw it over. If the canvas hose must be shifted for a considerable distance, a little more water must be fed into the hold of the ship, and then the valve 21 for priming must be quickly shut off. A canvas hose that has been emptied of water is very light and can be easily carried by an assistant for two or three seconds. After this, the valve 21 must be quickly opened again.

If the assistant has been slow and the fish pump draws the water out, the starting valve 33 may be throttled. The valve 33 is fully opened once more as soon as the assistant transfers the hose.

Towards the end of unloading, the valve 21 must be gradually throttled in order to pump out the fish in the kungas. When all of the fish is pumped out, the valve 21 is quickly closed, and the spout 27 is lowered to the bottom; at the same time, the needle of the vacuum gauge 14 must be carefully watched. As soon as the needle begins to oscillate rapidly, which indicates that the intake pipe is taking in air, the starting valve must be throttled and the pipe raised. The starting valve cannot be entirely closed : this may be done only after the pipe has been raised, when all of the water will have been pumped out of it. Otherwise, the water in the pipe can gush back into the hold as a result of a drop in the vacuum in the mixing chamber caused by cutting off the inflow of the stream. The assistant raises the hose. The water cannot be completely pumped out of the hold since the spout cannot be lowered right down to the floor, to which it could adhere. A 2- to 3-cm layer of water remains in the hold.

In order to reduce the residual layer of water, an opening measuring 0.6 x 0.5 m and covered with a lid, is made in the poel* of the hold in advance. When the lid is opened, almost all of the water may be removed from under the poel, and incidentally, the space between the inner bottom and the hull [the bilge] washed, by lowering the spout of the intake pipe to this area.

---

* See Translator's note, p 113 .

While the work is being carried out, the assistant must see to it that the spout 27 is not lowered too far down and does not adhere to the floor of the hold. If the spout adheres to the floor, the mixture of fish and water will not be able to get into the pipe. The spout should be situated at a distance of 25 to 30 cm from the bottom of the kungas. It is recommended that the spout be placed at an angle of 10 to 15°.

For greater efficiency in operation, and to enable several points to be serviced, the fish pump may be mounted on a ship, i.e., a mobile installation may be made for unloading. The installation and operation of a fish pump on board a kungas differ in no way from the installation and operation of a stationary unit on shore. In this case, the intake pipe from the centrifugal pump is passed into the bilge of the ship or is let out over the side (whichever is more convenient according to the place of installation) and a Kingston valve is installed. When a fish pump is mounted on a ship, the latter should have a cargo capacity of 16 to 20 tons. The hoisting device for the pipe 26 is mounted on the same ship.

Operational Trouble and its Elimination

If the centrifugal pump does not create the required pressure, a check must first be made to see whether it has a normal number of revolutions. If the number of revolutions is insufficient, the engine must be inspected and the cause of the trouble eliminated. Where the number of revolutions is normal, a check must be made to see if any inleakage of air is observed in the intake pipe 7 or the valve 6. For inspection, the intake valve 5 and the bypass valve 34 must be opened when the pump is not operating. At the same time, water from the circulation tank 9 will flood the entire main line and will create a certain pressure. All leakages will easily be noticeable from inflows. Special attention /66 should be directed to the stuffing box of the pump.

If there are no inleakages and the number of revolutions is normal, but the pump still creates no pressure, the pump should be opened and examined. For inspection, the intake T-pipe 4 is detached at its flanges and is removed from the pump cover. The interior of the operating wheel will now be easily seen.

If some foreign objects that have accidentally gotten in are between the blades, they must be withdrawn; after this, the pump will operate normally.

If, when the starting valve 33 is opened, a powerful jet of water escapes from the diffuser, starting has been carried out improperly; the valve must be closed and the pump started more carefully.

Occasionally, in spite of a careful start, a vacuum still does not form; a check should then be made to see whther something has gotten into the nozzle 17 or the vent 12. For inspection, the pressure gauge 16 and the vacuum gauge 14 must be unscrewed and the openings examined alternately with an electric lamp. If the examination is made from the diffuser side, it will be clearly evident which is obstructed-the vent or the nozzle. After they have been cleaned, the fish pump will operate normally.

If the vacuum is very high (400 to 500 mm), and fish are still not drawn in, the spout 27 of the intake hose must first be examined. It has either adhered to the bottom of the ship or is plugged up with some foreign object (a board, matting, a net, a bag, or a tarpaulin). Here it should be remembered that foreign objects that have adhered during work, when the fish pump is stopped fall off the bell mouth because of the drop in the vacuum. Therefore, in order to find out the reason [for the trouble] and to eliminate it, an inspection should be carried out without stopping the fish pump. Sometimes it is sufficient rapidly to throttle the valve 33 and, as soon as the vacuum drops to 20 or 30 mm, to open it again immediately. Simultaneously the foreign object will fall from the bell mouth and the pump will operate normally. If a board gets in, it can pass into the pipe, but will jam in the elbow. Then a normally operating fish pump will either not convey any fish at all, or will convey it in small quantities and seriously damaged. Occasionally it is sufficient to open and close the valve 33 several times rapidly in order to eject the board. If however, the board has become solidly jammed, the intake hose must be dismantled and the board removed.

If fish is damaged when passing through the fish pump, the height to which the fish is hoisted should be checked. Where herring is being unloaded, the height to which it is raised should not exceed 2.7 m above the level of the water in a given water area; the corresponding height limit for salmon when it is unloaded is 3.2 m. A check must be made to see whether in the hose or in the diffuser there are projecting drops of metal or burrs, unnoticed during manufacture, that do not coincide with the openings of flanges, etc. Where there is careful inspection of parts at the time of assembly, ordinarily such occurrences are eliminated before the pump 67
is put together. If, however, they have not been eliminated, they must be removed in the course of dismantling and

assembling the pump once more. Maintenance on the centrifugal pump and the engine is performed in the usual sequence.

Technical Description of the NCh-3 Water-Jet Fish Pump

Fish output during continuous operation, in centners [1 centner= 100 kg] per hour	600
Coefficient of use of fish pumping unit	0.25 to 0.5
Normal concentration of fish in mixture, in %	17 to 20
Greatest permissable concentration, in %	30
Efficiency when operating with pure water	0.28 to 0.3
Power consumption in hp	35 to 40
Height of lift from water level to centre of diffuser spout in m:	
for herring	2.7
for fish of the salmon family	3.2
Efficiency of centrifugal pump in cubic metres per hour, allowing for supplying of hydraulic conveyer	420
Pressure of operating water at nozzle in metres of a column of water	12 to 14
Vacuum in mixing chamber in mm of a column of mercury	200

Basic dimensions in mm

Diameter	
of vent for herring, pink salmon and sockeye salmon	180
of vent for chum and coho	200
of intake pipe	250
of nozzle	82
of diffuser spout	350
of return pipe	250
of beginning and end of mixing chamber	200
of middle of mixing chamber	294
of pipes for supply of operating water	200
of pipeline for additional removal of water.	76
Length in mm	
of mixing chamber	805
of vent	500
of diffuser	1,500
of diffuser spout	1,500
of grating in circulation tank	1,500
of additional water separator	1,200
Size of wooden strips of water separator grating, in mm.	15 x 25

Spaces between strips, in mm	
for salmon	15 to 20
for herring	8 to 10
Angle of connection of branch intake pipe	30°
Distance from beginning of vent to end of nozzle, in mm	457

[Please ignore space below; text is continued on next page.]

8. The EKR-1 Water-Jet Fish Pump with Annular Delivery of Operating Water

In attempting to simplify the design of the water-jet fish pump and to improve its efficiency with the purpose of using it for pumping medium and small fish, I.V. Nikonorov developed a fish pump with an ejector action, in which the operating liquid was fed not through a central nozzle, but rather through an annular aperture situated in the inner part of the mixing chamber (see Fig. 14).

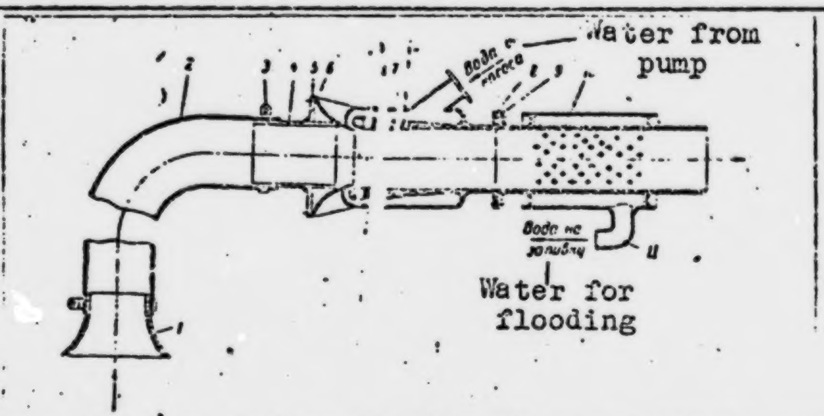


Figure 14 - Line diagram of working principle and operation of EKR-1 fish pump:

1- spout; 2- intake hose; 3- collar; 4- branch pipe; 5- flange of branch pipe; 6- bell mouth; 7- operating chamber; 8- gasket; 9- diffuser flange; 10- closed diffuser; 11- branch pipe for diverting water from diffuser.

As early as 1943 Professor P.A. Sviderskii indicated that the annular feeding of operating water would permit the central admission of fish into the mixing chamber, in consequence of which the best conditions would be secured for preventing damage to fish.

The above analysis of the effect on fish of a jet of operating liquid emerging from a central nozzle shows that where the water makes an annular approach, there may be expected a more even distribution of velocities through the cross section of the mixing chamber, and consequently, calmer conditions for the passage of fish through a water-jet apparatus.

The design of the EKR-1 fish pump includes a cylindrical working chamber serving simultaneously as a mixing chamber and a vent. The working chamber is surrounded by a water jacket, from which, within the chamber, there lead passages in the form of annular apertures that narrow smoothly at the places where they enter the chamber.

On the side on which the mixture of fish and water is drawn in, the working chamber has a curved, funnel-shaped opening, the narrow part of which smoothly adjoins the chamber in front of the annular aperture for delivering the operating water. To the funnel-shaped opening is fastened a branch pipe with a rigid intake hose on whose end is a conoid metal spout. /69

To the operating chamber on the injecting side is attached a closed diffuser consisting of a cylindrical perforated pipe surrounded by a jacket having a branch outlet pipe. Thus in contrast to the NCh-3 fish pump, in the EKR-1 fish pump all structural parts in the path of the fish are of a smooth cylindrical shape.

The conversion of the kinetic energy of the stream of mixed water and fish into potential pressure energy takes place owing to the widening of the cross section of the stream of liquid in the diffuser, when the liquid, passing through the openings of the inner cylinder, fills the volume of the jacket. The mixture of water and fish, having shed part of its water in the diffuser, emerges from the fish pump in a smooth stream.

It is assumed that on the path of further movement of the mixture of water and fish it will be possible to feed this mixture into a second such apparatus arranged in sequence and thus to create a two-stage water-jet fish pump possessing a doubled lifting capacity.

For the conditions of the Volga River-Caspian Sea area, where variations caused by the seasons and wind in a given body of water (the river) are great, the EKR-1 fish pump in its single-stage version was mounted on a wharf in combination with an inclined reticulate conveyer delivering fish to a second belt conveyer. The reticulate conveyer was to separate the fish from the water and raise it to an additional height.

The reticulate conveyer, together with the water-jet apparatus mounted on it, was secured with hinges in its upper part and could be raised and lowered, revolving around the axis of the driving drum, which obviated the installation of a pontoon for mounting the fish pump.

Operating water was supplied to the fish pump through a hose from a centrifugal fish pump mounted on the same spot (on the wharf). For convenience in maneuvering the intake hose, the fish-pumping installation was equipped with a crane arm. Thus a complete fish-pumping station was installed on the wharf (see Fig. 15).

The EKR-1 fish-pumping installation was tested on pumping live fish (carp, bream and others). In some cases the tests gave good results; in others, improvement was required in the operation of the fish pump and in its design.

The design characteristics of the EKR-1 fish pump, and mechanical characteristics which were obtained during tests carried out on it, show that it is much lighter and more economical than the NCh-3 fish pump. Thus the weight of an EKR-1 installation without its engine is one-quarter of the weight of an NCh-3. Similarly, in the EKR-1 the power input is approximately half, the water consumption, one-third, and the operating water pressure, from 1.5 to 1.8 times less than in the NCh-3. The height, however, to which fish is raised above the water level in a given body of water (3 m) does not exceed the height to which fish is raised by the NC_h-3 fish pump, while the amount of damage to fish in the water-jet apparatus is much greater, and the overall efficiency output in terms of water and fish far poorer, than in the NCh-3. /70

Work on improving the design of a water-jet fish pump with annular delivery of operating water should be continued. There is reason to assume that the results of this work will be favourable.

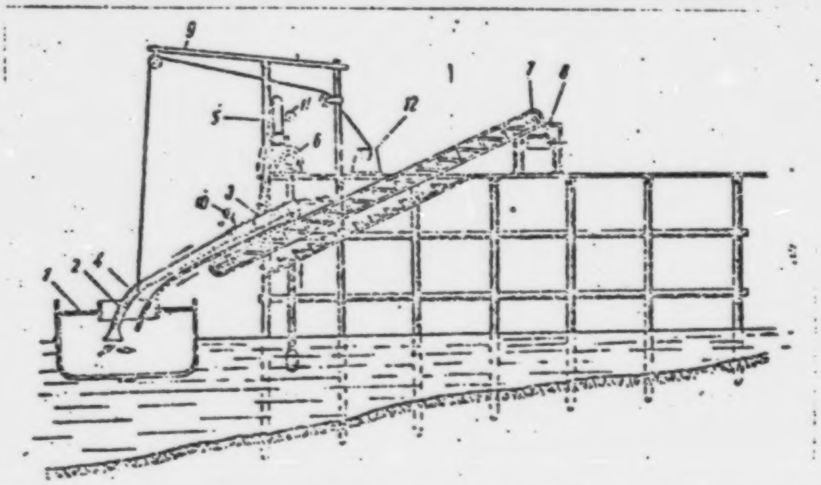


Figure 15 - Installation of an EKR-1 fish pump on a wharf:

1- ship with fish; 2- intake hose of fish pump; 3- EKR-1 fish pump; 4- hose for delivering water to ship; 5- pressure hose of centrifugal pump; 6- centrifugal pump; 7- reticulate conveyer; 8- belt conveyer; 9- maneuvering crane arm; 10- vacuum gauge; 11- pressure gauge; 12- winch.

Technical Description of EKR-1 Water-Jet Fish Pump

Height to which fish is raised by water-jet apparatus, in m	3
Discharge of operating liquid delivered by centrifugal pump, in m^3 per hour	120

Input, in kilowatts	19 to 21
Pressure of operating water at nozzle in metres of a column of water	1.5 to 8
Vacuum in mixing chamber, in mm of a column of mercury, up to	160
Efficiency of unit (tentatively)	0.37
Weight of unit without engine, in kg	500

9. A Portable Water-Jet Fish Pump

Designed by B.T. Burkal'tsev

The use of fish pumps for unloading salted fish from tubs has always encountered difficulties because of the fact that fish pumps of even the smallest type sizes are, by their weight and dimensions, highly inconvenient for moving from tub to tub, especially within salting sheds, where all operations are hindered by the lack of space in the passageways between the tubs. If the tubs are covered with flooring and the fish pump has to be moved along the flooring, the latter sags, which also complicates considerably work on / 71
moving the fish pump.

At the same time, it is highly advisable to use fish pumps for unloading salted fish from tubs, since hydraulic methods are the most efficient, hygienic and convenient for conveying fish for packing.

In attempting to create a light, mobile fish pump, B.T. Burkal'tsev, an engineer of the Osipenko Fish Plant, designed a portable ejector supplied with an operating liquid (brine) from a stationary stand pipe supplied with branch pipes and connecting pieces for rapid switching on. The ejector designed by B.T. Burkal'tsev (see Fig. 16) is of light weight - about 6 kg. It unloads fish from tubs into a concrete trough that is laid near the tubs that are being unloaded and carries off a mixture of brine and salted fish to the receiving device of a culling installation.

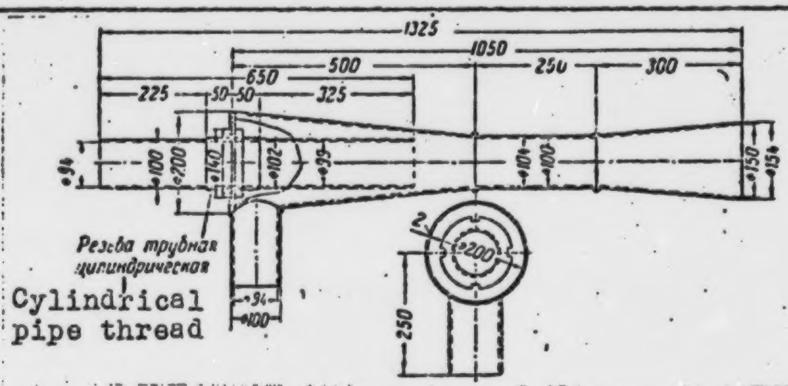

1325
1050
500
250
300
650
225
50
50
325
⌀94
100
⌀200
⌀140
⌀102
⌀99
⌀104
100
⌀150
⌀154
2
⌀200
250
⌀94
⌀100
Резьба трубная цилиндрическая
Cylindrical pipe thread

Figure 16 - Diagram of a portable water-jet fish pump designed by B.T. Burkal'tsev.

The ejector is designed for unloading small fish - anchovy, tiulka and goby. It consists of two cones of different length connected in their narrow areas by a cylindrical insert (a vent), and of a cylindrical intake pipe 94 mm in diameter inserted into a longer cone for 2/3 of the latter's length.

The structure is welded of thin sheet iron.

The intake pipe is inserted into the cone through a larger cross section in such a way that an annular aperture forms between it and the walls of the cone. A branch pipe 94 mm in diameter is welded on the side in the wide part of the cone. The operating fluid, in this case concentrated brine, is fed along the branch pipe towards the ejector. The operating fluid fills the cavity between the walls of the cone and of the intake pipe and bursts through the annular aperture into a part of the cone that is free of the pipe, producing the effect of drawing in the mixture of brine and salted fish.

In the remaining third of the large cone there takes /72
place the mixing of the operating fluid and the fish and brine mixture, which then pass to the cylindrical vent and further to a dilating cone which acts as a diffuser. In the diffuser the velocity of the stream drops, and the pressure increases, as a result of which the mixture of brine and salted fish proceeds from the ejector into the hydraulic conveyer.

On the free end of the intake pipe is put an intake hose equipped with a conical dilating spout (a funnel) with a wooden handle which is used for maneuvering the intake hose (see Fig. 17).

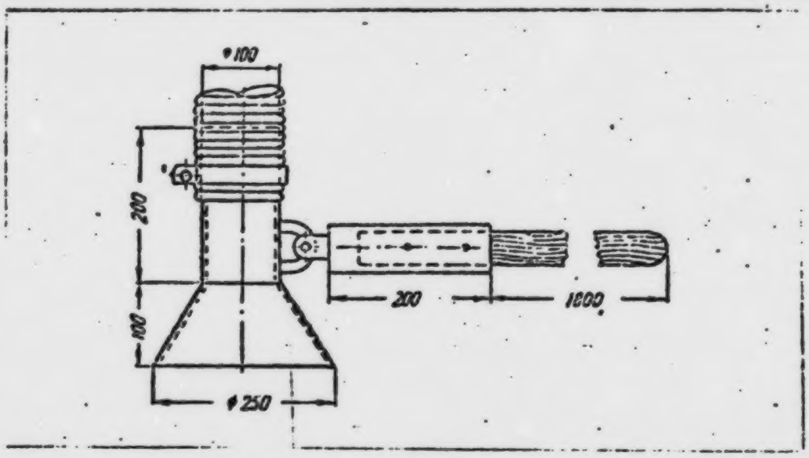


Figure 17 - Intake funnel for water-jet fish pump designed by B.T. Burkal'tsev.

Small salted fish, in the process of pickling, cakes in the tub, forming a monolithic caked mass which is difficult to scoop or suck in. In order to facilitate the conditions under which the fish is drawn in, together with the ejector there is used a hydraulic loosener consisting of a metal shaft with a variable cross section, narrowing towards its outlet (see Fig. 18). The shaft is inserted into a hose with a diameter of 102 mm. The hose is connected by a quickly detachable connecting piece (clutch) to a brine delivery conduit.

The brine conduit for supplying the ejector and the hydraulic loosener has a diameter of 100 mm and delivers saturated brine with a specific gravity m = 1.2 at the rate of up to 100 cubic meters per hour where there is a pressure head of about 25 meters of a column of water. A 4 NDB pump is used for delivering the brine.

The brine circulates in a closed system: pump - brine conveyer - reconcentrator - pump. In the process of work it is continuously cleaned and its concentration is restored.

The output of B.T. Burkal'tsev's ejector during the unloading of salted fish from tubs has amounted to 8 to 10 tons per hour. No mechanical damage to fish has been observed inside the ejector. /73

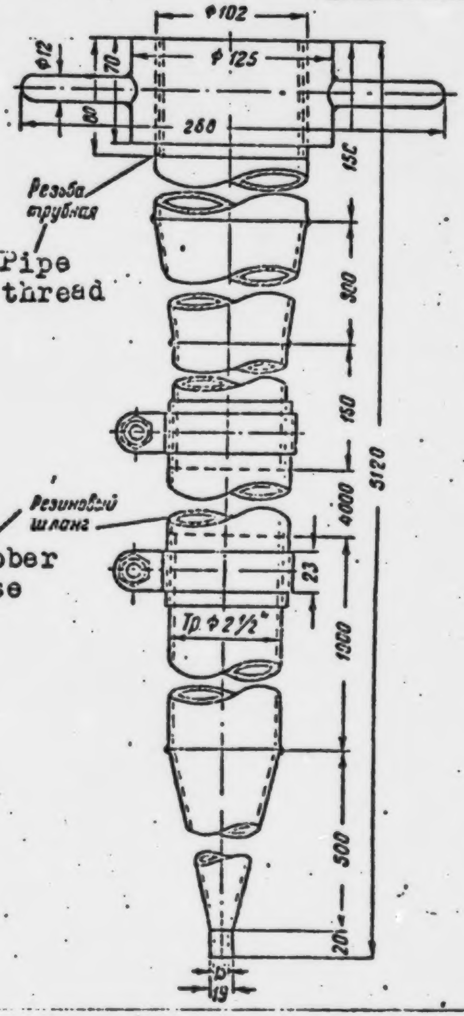

Φ102
Φ12
70
Φ125
80
288
150
Резьба трубная
Pipe thread
300
150
3120
4000
Резиновый шланг
Rubber hose
23
Тр.Φ2½"
1900
500
20
D
19

Figure 18 - Hydraulic loosener of small salted fish in a tub.

Chapter IV

CENTRIFUGAL FISH PUMPS

1. Operating Principle and Purpose of Individual Parts

Centrifugal fish pumps represent one variety of centrifugal pumps, i.e., of hydraulic machines serving to transfer liquids and liquid mixtures under the action of centrifugal force (see Fig. 19).

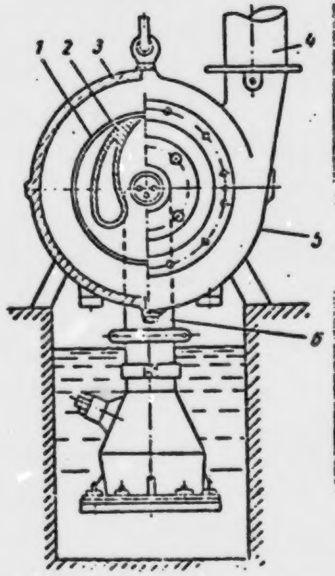


Figure 19 - Diagram of the arrangement of a centrifugal fish pump:

1- fish pump wheel; 2- blade of wheel; 3- housing;
4- branch pressure pipe; 5- distributor (volute);
6- intake pipeline with return valve (snore piece).

All of the theoretical conclusions and calculations concerning ordinary centrifugal pumps apply in equal measure to centrifugal fish pumps.

Centrifugal pumps belong to [the class of] cantilever pumps with a double-bladed wheel that is designed for the free passage through its inner cavities of pumped liquid and of solid bodies in this liquid. This feature of the technological purpose of the fish pump has found expression in its design, which is characterized by free, broad conduits within the operating wheel and by the smoothness of all surfaces coming into contact with the mixture of fish and water that is being conveyed.

The operating wheel is a basic working element of any centrifugal pump. In centrifugal fish pumps it consists of two discs, between which are situated two blades (vanes or impellers). The latter set the liquid, or the working mixture that is being pumped, in rotary movement around the axis of the wheel: the liquid is thrown by centrifugal force from the wheel into the distributor. Within the wheel the liquid continually moves along the blades from the centre of the wheel to the periphery, as a result of which a vacuum is established in the centre of the /75 wheel, and there is increased pressure on the periphery. The operating mixture is brought to the centre of the wheel through the intake branch pipe of the fish pump housing. In contrast to ordinary centrifugal pumps, which can have several wheels, the existing designs of centrifugal fish pumps have only one wheel.

The distributor is intended for diverting the pumped fluid from the wheel to the delivery conduit. In centrifugal fish pumps the pump housing (a volute) acts as a distributor. In the distributor the movement energy that is absorbed by the fluid as a result of interaction with the wheel, is converted into pressure.

The housing of the centrifugal pump consists of a volute that is confined on the sides by front and rear covers. In the rear cover there is an opening for the fish pump shaft, and there are recesses for the pins with which the volute is fastened to the frame. In the forward cover is a branch intake pipe. To it is fastened the intake conduit. The volute part[*] of the housing proceeds to the branch delivery pipe, to which the pressure line [delivery conduit] is in turn fastened. The internal cavity of the housing is called the chamber.

The elements[*] of the housing are made in the shape of a spiral. The shape of the spiral enables the fluid that is thrown back by the wheel to be received without undue impact. In front of the delivery opening the volute turns into a conical dilating branch pipe (a diffuser), in which the increase in pressure in the liquid actually takes place.

In the highest part of the housing there is an opening that connects the chamber with the atmosphere and is designed for priming the pump and periodically releasing air from the housing.

---

[*] *Translator's note.* Both "part" and "elements" are here used as equivalents of the Russian *obrazuyushchaya*.

The intake conduit consists of a pipe or reinforced flexible hose supplied at its end with a return valve (a snore piece), which is immersed in the liquid that is being pumped, or with a spout. At its other end the intake hose is made fast to the intake opening in the forward cover of the housing. When the return valve is installed on the end of the intake conduit, the pump, the conduit and the pump chamber must be primed with liquid before starting. A centrifugal pump cannot work without priming.

Recently, the drawing of liquid into the pump through the intake conduit has been used in place of pump priming. The liquid is drawn in using small vacuum pumps. In this case the return valve is not installed on the intake conduit, but in its place on the delivery conduit there should be a slide valve shutting off the access of air from the delivery conduit to the chamber.

There also exists the method of priming a centrifugal fish pump with the aid of an ejector [pump] built into the branch intake pipe. In this case return valves are not installed.

The branch delivery pipe represents a continuation of the [7 volute diffuser. To it is fastened the delivery conduit. If the diameter of the latter is greater than that of the branch delivery pipe, an additional diffusor in the form of a conical branch pipe is installed between them.

The transmission represents the shaft on which the operating wheel is fastened. The shaft lies in bearings that take up the radial and axial stresses from it. The frame is the support for the bearings. The drive device is made in the form of a clutch, a pulley or a sprocket.

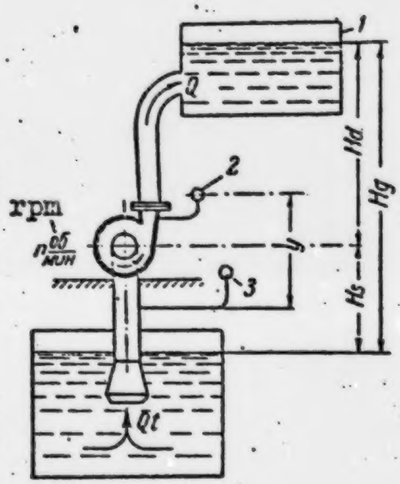


Figure 20 - Diagram of the operation of a centrifugal fish pump:

1 - supply tank; 2 - pressure gauge; 3 - vacuum gauge.

The stuffing box is located on the rear cover of the fish pump at the place where the shaft passes through. It prevents the entry of air into the pump chamber. The stuffing box is packed with graphite cord and is provided with a small tube through which water is continually fed to the stuffing box during operation, forming a hydraulic collar. When there are leakages in the stuffing box, water rather than air is drawn into the pump chamber from this collar. In this way, the entry of air into the fish pump chamber is prevented.

The fittings of centrifugal fish pumps consist of a pressure gauge, a vacuum gauge, return valves on the intake or delivery conduit, and taps on the pipes connecting the fish pump chamber to the atmosphere and the stuffing box.

2. The Basic Operating Parameters of a Centrifugal Fish Pump and Brief Data from the Theory of Fish Pumps

The essence of operation of a centrifugal fish pump consists in the fact that it uses the energy supplied to it N_e for conveying a certain quantity of working mixture Q in a unit of time t to a height N_g at a rotation speed of the wheel n rpm and an efficiency η (see Fig. 20). Hence follows the concept of the basic parameters of the operation of centrifugal fish pumps.

Delivery and Discharge

The quantity of liquid conveyed by a fish pump per unit of time is termed the delivery or discharge of the pump. The delivery is usually expressed in litres per second, litres per minute, or cubic metres per hour. A distinction should be made between the delivery of the pump $\underline{Q}$, developed by it when working with /77 pure water, and its discharge. i.e., the quantity of fish that it transships per unit of time, measured in tons per hour.

$$Q = Q_t - q. \qquad [30]$$

where $\underline{Q}$ is the actual delivery in litres per second, litres per minute, or cubic metres per hour;

$\underline{Q_t}$ is the theoretical delivery (at the beginning of the intake pipe) in litres per second, litres per minute, or cubic metres per hour;

$\underline{q}$ represents losses through slits or cracks in litres per second, litres per minute, or cubic metres per hour.

Part of the liquid that emerges from the operating wheel of the fish pump is directed not into the delivery conduit, but rather into the cavities between both walls of the operating wheel and both vertical walls of the housing. The liquid penetrates into these cavities through spaces (slits) between the rim of the operating wheel and the annular recess in the fish pump housing. Subsequently, this liquid emerges from the cavities between the housing and the operating wheel through a space (slit) between the edge of the intake opening of the wheel and the edge of the branch intake pipe of the housing. Thus around both walls of the wheel is established a continuous circulation of the liquid flowing through the slits between the wheel and the housing and reducing the overall efficiency developed by the fish pump. The quantity of the liquid involved in this circulation actually comprises the losses through slits.

The designers of pumps, including fish pumps, are attempting to decrease losses through slits, for which purpose they are trying to reduce the sizes of the slits themselves.

Pressure Head

The height to which liquid is conveyed by a fish pump is termed pressure head. The theoretical height to which a fish pump conveys [liquid] is made up of the geometric height of conveyance (reckoned between the level of the liquid at the intake pipe and the level of liquid in the supply tank (see Fig. 20)), the sum of the hydraulic resistances in the intake and delivery conduits, and the resistance of the pump itself.

If the end of the delivery conduit is not immersed below the surface of the liquid in the receiving tank, the geometric pressure head is reckoned from the level of the liquid at the intake conduit up to the axis of the terminal opening of the delivery conduit

$$H_t = (H_s + H_d) + H_{wr} + H_{wp} = H_g + H_{wr} + H_{wp}, \qquad [31]$$

where: H_t is the theoretical pressure head, in metres of a column of water;

H_s is the height to which [the liquid] is drawn in up to the axis of the wheel, in metres;

H_d is the height to which [the liquid] is delivered from the axis of the wheel, in metres;

H_g is the geometric pressure head, in metres;

H_{wr} is the value of the hydraulic resistances in the intake and delivery conduits, in metres of a column of water;

H_{wp} is the value of the hydraulic resistances in the pump housing, in metres of a column of water.

The manometric pressure head is the term applied to the /78 sum of the readings of the pressure gauge on the branch delivery pipe of the fish pump and of the vacuum gauge on the branch intake pipe plus the geometric elevation between the centre of attachment of the vacuum gauge to the intake pipe and the centre of the pressure gauge

$$H_{м} = h_{м} + h_{\underset{v}{в}} + y, \qquad [31]$$

where: H_m is the manometric pressure head, in metres;

h_m represents the readings of the pressure gauge, converted to metres of a column of water;

h_v is the value of rarefaction according to the vacuum gauge and converted to metres of a column of water (in calculations it must be remembered that the vacuum gauge shows a residual pressure that is lower than the atmospheric pressure);

y is the vertical distance between the axis of the pressure gauge and the axis of attachment of the vacuum gauge, in metres.

$$H_м = H_g + H_{wr} = H_t - H_{wp}. \qquad [31б]$$

The Power of a Fish Pump

The power fed to a fish pump, or the shaft horsepower of the fish pump, is expended both on useful work and on making up hydraulic and mechanical losses. Accordingly, the following are distinguished: the useful horsepower N, the theoretical or indicated horsepower N_1, and the shaft horsepower of the fish pump N_e.

The useful horsepower is expressed by the formula

$$N = \frac{\gamma Q H_м}{75}\ \underset{\text{hp}}{\text{л. с.}} = \frac{\gamma Q H_м}{102}\ \text{квт}, \text{—kw} \qquad [32]$$

where: γ is the density of the working mixture that is being pumped, in kilograms per litre;

Q is the actual delivery in litres per second;

H_m is the manometric pressure head in metres of a column of water.

The theoretical horsepower may be determined from the formula

$$N_t = \frac{\gamma Q_t H_t}{75}\ \underset{\text{hp}}{\text{л. с.}} = \frac{\gamma Q_t H_t}{102}\ \text{квт}, \text{ kw} \qquad [32a]$$

where: Q_t is the theoretical delivery in litres;

H_t is the theoretical pressure head in metres of a column of water.

The shaft horsepower of the pump is expressed by the formula

$$N_e = \frac{N}{\eta}, \qquad [32б]—b$$

where N_e is the power supplied, in hp or kw;

η is the full efficiency of the pump.

Pump Efficiency /79

The full efficiency of the pump η is the ratio of the useful horsepower to the shaft horsepower of the pump

$$\eta = \frac{N}{N_e}. \qquad [33]$$

The full efficiency is the product of several individual efficiencies.

$$\eta = \eta_h \cdot \eta_v \cdot \eta_m, \qquad [33a]$$

where η_h is the hydraulic efficiency;

η_v is the volumetric efficiency;

η_m is the mechanical efficiency.

. The volumetric efficiency characterizes volumetric losses and is the ratio of the actual delivery to the theoretical

$$\eta_v = \frac{Q}{Q_t} = \frac{Q_t - q}{Q_t}, \qquad [33б]—b$$

where Q, Q_t, and c are the same as in formula [30].

The hydraulic efficiency characterizes losses in pressure head and is the ratio of the manometric pressure head to the theoretical

$$\eta_h = \frac{H_м}{H_t} = \frac{H_t - H_{wp}}{H_t}, \qquad [33в]—v\ [c]$$

where H_m, H_t and H_{wp} are the same as in formulas [31] and [31a].

The mechnical efficiency characterizes the sum of the losses of power on friction in the bearings of the operating wheel (against the working mixture), in the stuffing-boxes, etc. It is the ratio of the useful horsepower to the supplied shaft horsepower of the pump

$$\eta_m = \frac{N_t}{N_e}. \qquad [33r]— g [d]$$

The full efficiency of centrifugal fish pumps may, on the basis of practical data, be assumed to be $\eta = 0.55$ to 0.65 in work with pure water.

The efficiency of a pump should not be confused with the coefficient of use of a fish-pumping installation.

The Rotation Speed of the Operating Wheel

The rotation speed of the operating wheel is characterized by the number of revolutions of the wheel per minute and is designated n rpm. Centrifugal fish pumps usually have

$$n = 300 \div 1000 \text{ об/мин.} \quad \text{rpm}$$

The Coefficient of Rapidity

/80

The coefficient of rapidity n_s is the specific number of revolutions of the wheel of a given fish pump and is equal to the number of revolutions of a single (model) pump, i.e., of a pump which, being geometrically similar to the given pump, provides a pressure head of 1 metre, developing a useful horsepower of 1 hp at its greatest efficiency. The formula of the coefficient of rapidity

$$n_s = 3{,}65 \frac{n\sqrt{Q}}{\sqrt[4]{H_{\text{м}}}}, \qquad [34]$$

where: n is the number of revolutions of the wheel of the given pump per minute at normal rotation speed;

Q is the actual delivery in cubic metres per second;

H_m is the manometric pressure head in metres of a column of water.

The working mixture transferred by the fish pump moves together with the wheel and within the latter completes a complex movement. In the actual working process in the centrifugal pump, the liquid moves turbulently. This circumstance complicates the picture of movement of the liquid to such an extent that it renders impossible a theoretical analysis of the operation of the pump. Therefore when the operating process of a centrifugal pump is examined, it is assumed that an ideal liquid is being transferred which has no internal friction and moves in the manner of a laminar flow, and that the operating wheel has

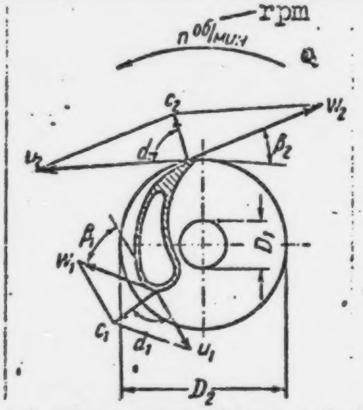


Figure 21 - Diagram of the operation of the working [operating] wheel of a fish pump.

an infinitely large number of thin blades. Correction factors that allow for the reality of the liquid in the pump, the finite number of blades on the wheel, and their actual shape, are introduced into the expressions derived on the basis of this assumption.

The liquid enters the wheel with an absolute speed c_1 (see Fig. 21) which is the geometrically resulting [value] of the transposable speed u_1, tangential to the inner circumference of the wheel, and the relative speed w_1, tangential to the blade of the wheel at the entrance. Passing through the channels of the operating wheel, the liquid increases its absolute speed to c_2 with a simultaneous change in the transposable and relative speed to u_2 and w_2, tangential to the rim and the blade at the outlet from the wheel.

Bernulli's equation (see formula [9] has been made the basis for research on the operation of a centrifugal pump.

On the basis of this equation there has been derived the fundamental theoretical equation of a centrifugal pump for an ideal liquid [81

$$H_{t\infty} = \frac{u_2 c_2 \cos \alpha_2 - u_1 c_1 \cos \alpha_1}{g}, \qquad [35]$$

where: $H_{t\infty}$ is the theoretical pressure head developed by the pump with an infinite number of blades and an ideal liquid;

u_1 and u_2 are the transposable speeds of the liquid at the entrance to and the outlet from the wheel;

s_1 and s_2 are the absolute speeds at the entrance to and the outlet from the wheel;

α_1 and α_2 are the angles between the directions of the transposable and absolute speeds at the entrance to and the outlet from the wheel;

g = 9.81 m/ sec.^{2}

Actually, the angle $\alpha_1 = 90^\circ$, and, consequently, $\cos\alpha_1 = 0$, then

$$H_{t\infty} = \frac{1}{g} u_2 c_2 \cos\alpha_2. \qquad [35a]$$

For conversion to the rating equation of a centrifugal pump, the right member of the theoretical equation is multiplied by the hydraulic efficiency and by the coefficient of circulation K, which allows for the finite number of blades on the wheel.

The rating equation of a centrifugal fish pump appears as

$$H_{м} = \eta_{h} K H_{t\infty} = \eta_{h} K \frac{1}{g} u_2 c_2 \cos\alpha_2, \qquad [35б]$$

where H_m is the manometric pressure head;
η_h is the hydraulic efficiency;

s_2 and u_2 are the same as in formula [35]

K is the coefficient of circulation allowing for the dimensions of the wheel and the number of blades.

The coefficient of circulation is usually determined from the formula

$$K = \frac{1}{1 + \frac{2\varphi}{z\left(1 - \frac{D_1^2}{D_2^2}\right)}} \qquad [36]$$

where: φ is the empirical coefficient, equal to 0.8 to 1:0;

z is the number of blades on the wheel; for a fish pump usually $z = 2$;

D_1 and D_2 are the diameters of the peripheries of the entrance to and outlet from the wheel.

According to Sviderskii, $K = 0.56$ to 0.84. For the RB-100 centrifugal fish pump, which has $z = 2$ and $\frac{D_1^2}{D_2^2} \approx \frac{1}{9}$ where $\varphi \approx 0{,}9$, $K \approx 0{,}56$.

3. The Operating Characteristics of Centrifugal Fish Pumps /82

The relationships between the discharge of a fish pump Q litres/per second and the other parameters of its operation, i.e., the pressure head H, the power N and the efficiency η, where the constant number of revolutions of the operating wheel n = const, are termed the characteristics of a centrifugal fish pump. The graphic representation of these relationships in the form of curves is termed the operating description of a centrifugal fish pump. In Fig. 22, a, b, and v, are depicted the operating descriptions of the RB-100 and RB-150 fish pumps. On the x-axis are plotted the values of the discharge Q, and on the y-axis, the values of the pressure head H, the power N, and the efficiency η.

As may be seen from an examination of the operating characteristics of RB fish pumps, the analogous curves on them are completely monotypic for each make of fish pump. Curve $Q - H$ shows that the greatest pressure head is developed by the fish pump when its delivery is at zero, i.e., when the delivery conduit is entirely shut off.

The fish pump develops the least pressure head at its greatest discharge, i.e., when the conduit valve is completely opened. The curve $Q - N$ shows that when the discharge is increased and when the pressure head developed by the fish pump drops simultaneously, the power that it requires, i.e., the consumption of energy, grows continually and reaches a maximum at the greatest discharge and the least pressure head. The curve $Q - \eta$ shows that where n = const, the efficiency of a centrifugal fish pump is not constant, and that, depending upon the discharge of the pump, it changes, increasing from zero to a maximum and then dropping somewhat.

The characteristics of centrifugal fish pumps change depending upon the number of revolutions of the pump wheel. A centrifugal fish pump, like any centrifugal pump, performs best in the areas of discharge, pressure head and efficiency at a certain optimum number of revolutions of the operating wheel that is normal for it. For each number of revolutions of the wheel an operating characteristic can be plotted by converting the parameters of the work of the pump according to the formula for the dynamic similarity of movement of liquid in an operating wheel that shows how the basic parameters of the work of a centrifugal pump change when the number of revolutions changes.

$$d_{\text{к}} = \text{const} \begin{cases} \dfrac{Q_1}{Q_2} = \dfrac{n_1}{n_2}; & [37] \\ \dfrac{H_1}{H_2} = \left(\dfrac{n_1}{n_2}\right)^2; & [38] \\ \dfrac{N_1}{N_2} = \left(\dfrac{n_1}{n_2}\right)^3. & [39] \end{cases}$$

Here n_1, Q_1, H_1 and N_1 are parameters of the operation /84 of a centrifugal fish pump at a given number of revolutions;

n_2, Q_2, H_2 and N_2 are the same with another number of revolutions.

From formulas [37], [38], and [39] it follows that the discharge of a fish pump changes in proportion to the linear ratio of the numbers of revolutions [of the operating wheel] and that the pressure head changes in proportion to the square, and the input, in proportion to the cube, of the ratio of the numbers of revolutions of the operating wheel. At the same time, it has been conventionally assumed that the efficiency of a fish pump for each point of a characteristic remains invariable when the number of revolutions of the wheel changes. Actually, however, when the number of revolutions of the wheel alters, the efficiency also changes - and to a proportionately greater extent as the change in the number of revolutions is greater.

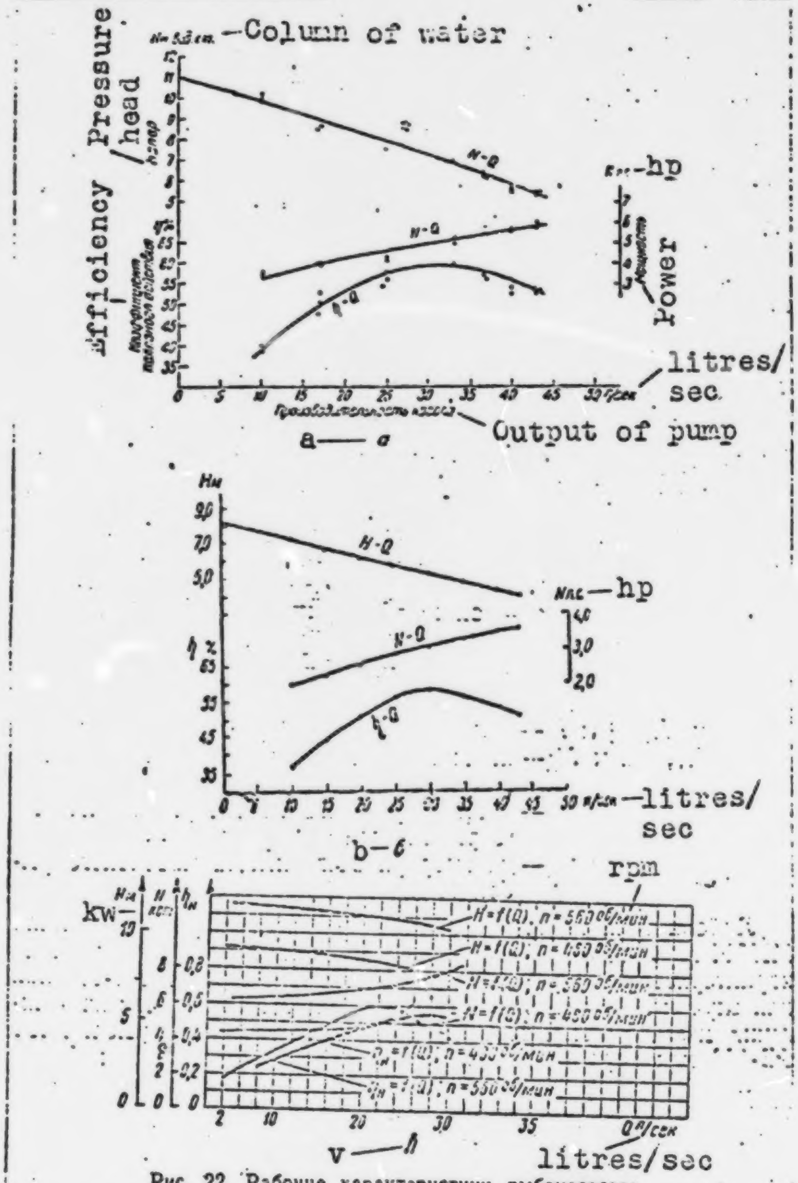


Рис. 22. Рабочие характеристики рыбонасосов: а—РБ-100 при n=852 об/мин.; б—РБ-100 при n=730 об/мин.; в—РБ- при n=480 и 560 об/мин.

Fig. 22 - Operating characteristics of fish pumps: a - RB-100 where n = 852 rpm; b - RB-100 where n - 730 rpm; v - RB-150 where n = 480 and 560 rpm.

In addition to the formulas of the dynamic similarity of the movement of liquid in one and the same wheel with different numbers of the latter's revolutions, there are also formulas from which, at a given number of revolutions of the wheel, the parameters of the operation of one centrifugal fish pump may be determined from the corresponding parameters of another fish pump that is a model of the first and is geometrically similar to it, but has different linear dimensions.

$$n = \text{const}\begin{cases} \dfrac{H}{H_{\text{м}}} = \left(\dfrac{D}{D_{\text{м}}}\right)^2; & [40] \\ \dfrac{Q}{Q_{\text{м}}} = \left(\dfrac{D}{D_{\text{м}}}\right)^3; & [41] \\ \dfrac{N}{N_{\text{м}}} = \left(\dfrac{D}{D_{\text{м}}}\right)^5. & [42] \end{cases}$$

Here H, Q, and N are the unknown* parameters of fish pump;

H_m, Q_m, and N_m are the parameters of operation of the model fish pump;

D is the diameter of the operating wheel of the fish pump for which calculations are being made;

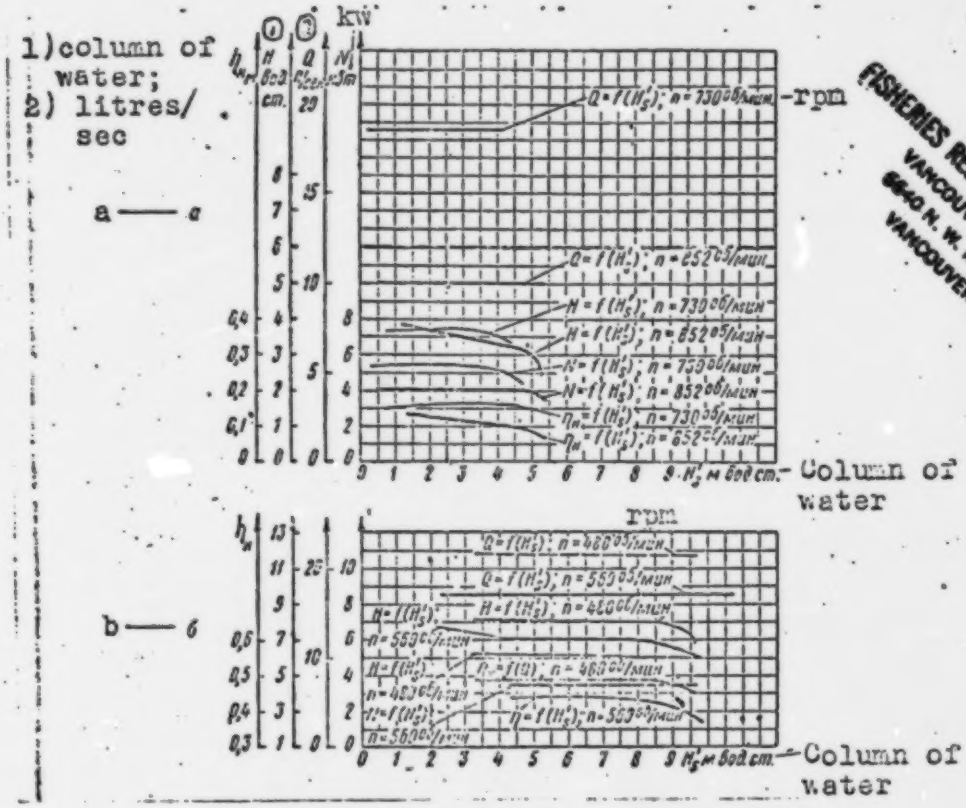
D_m is the diameter of the operating wheel of the model fish pump.

---

* Translator's note. The modifier of the word "parameters" that appeared in the text was iskopaemve, which means "minerals" or fossils". It is suggested, however, that iskopaemve is here a misprint for iskomve, meaning "unknown" or "desired quantities".

The mechanization laboratory of VNIRO and the Department of Hydraulics of the Moscow Engineering and Construction Institute have carried out a number of investigations on the actual determination of the characteristics of the RB-100 and RB-150 centrifugal pumps for cases where they are working with pure water and with a mixture of fish and water. The operating characteristics of the RB-100 fish pump for the former instance are depicted in Fig. 22, a and b.

Research in order to compare the performance of centrifugal pumps on pure water and on a mixture of fish and water was carried out on the RB-150 fish pump when it was working on the unloading of Baltic herring (large and small). The fish pump worked with different numbers of revolutions, from 552 to 622 per minute, and pumped both pure water and a mixture of herring and water at ratios of 1:5 to 1:21. It was established that for large and small Baltic herring the full pressure head $\underline{N}_{\underline{m}}$, the input $\underline{N}$ kw and the discharge $\underline{Q}$ m^3/ hour were practically equal to the corresponding values for pure water, the fluctuations ranging from - 0.5 to + 0.8%. /85 Consequently, the efficiency of the fish pump for both instances of work was practically the same. No similar research on pumping larger fish has hitherto been carried out, but, if



LIBRARY
FISHERIES RESEARCH BOARD OF CANADA
VANCOUVER LABORATORY
6640 N. W. MARINE DRIVE
VANCOUVER 8, B. C.

Figure 23 - Cavitation characteristics of fish pumps: a - RB-100 where n = 730 and 825 rpm; b - RB-150 where n = 480 and 560 rpm.

---

it is remembered that in pumping, the ratio of fish and water is not lower than 1:10, it may be assumed with sufficient validity that the performance of fish pumps when they are pumping pure water and a mixture of large fish and water will also be practically the same.

The cavitation characteristics plotted for the RB-100 and RB-150 fish pumps (see Fig. 23, a and b) when they are working on pure water, demonstrate their high intake capabilities. Thus for the RB-100 fish pump at 730 rpm, the guaranteed intake height is 4.5 m, and at 852 rpm it is 5.4 m. For the RB-150 fish pump at 480 rpm the guaranteed intake height is 9 m, and at 560 rpm, 9.4 m.

In practice,the intake height usually amounts to /86 about 4 m. The above data on cavitation characteristics, however, permit, where necessary, a larger intake height value to be assigned (for more detail on this matter, see Chapter VII).

The research carried out on the RB-100 and RB-150 fish pumps has shown them to have yet another interesting feature. It has been established that the whole indices in the formulas of dynamic similarity ([37], [38] and [39]) are inapplicable to the RB-100 and RB-150 fish pumps, since they do not give correct results. This can be explained by the small number of working blades in the wheels of the fish pumps (two) and by the low numbers of revolutions of these wheels. Therefore for RB-100 fish pumps where n = 730 to 852 rpm and for the RB-150 where n = 430 to 560 rpm, the formulas of dynamic similarity appear as follows:

$$\frac{Q_1}{Q_2}=\left(\frac{n_1}{n_2}\right)^{1,3}; \qquad [37a]$$

$$\frac{H_1}{H_2}=\left(\frac{n_1}{n_2}\right)^{1.7}; \qquad [38a]$$

$$\frac{N_1}{N_2}=\left(\frac{n_1}{n_2}\right)^{2.4}. \qquad [39a]$$

The symbols are the same as in formulas [37], [38], and [39].

4. The Theory of the Operating Process of a Centrifugal Fish Pump

Research into the Limits of Applicability of a Centrifugal Fish Pump

When being pumped by a fish pump, fish can be damaged either by the moving parts of the pump itself or by striking some obstacle in their path, for example, the walls of the pump volute.

Let us examine a case in which fish is damaged by coming into contact with the moving parts of a fish pump.

In Fig. 24 are shown three consecutive positions of a fish pump wheel. As may be seen from these illustrations, the fish cannot be crushed in the pump from a sharp blow by the blade, since the streamlined shape of the latter enables it to roll the fish, as it were, pressing and bending it, but not striking it. The clearance a in the plane of the longitudinal section of the wheel between the wheel itself and the volute is sufficiently large that with the given shape of the blades, which are bent back, the fish will not be cut between the blade and the entry rim of the branch delivery pipe (point B).

The fish can be crushed in two instances: if it is bent around the thick edge of the blade and if it is bent around the entry edge of the delivery opening. For crushing to take place, it is necessary that at least one end of the fish be caught, i.e., that it [the end] be sharply arrested. Arresting can occur if a large part of the length of the fish is in the intake conduit and the intake vent of the wheel. Arresting takes place in another position if a large part of the length /87 of the fish is located in the delivery conduit. The worst case is that in which both ends of the fish are arrested in the intake and delivery branch pipes.

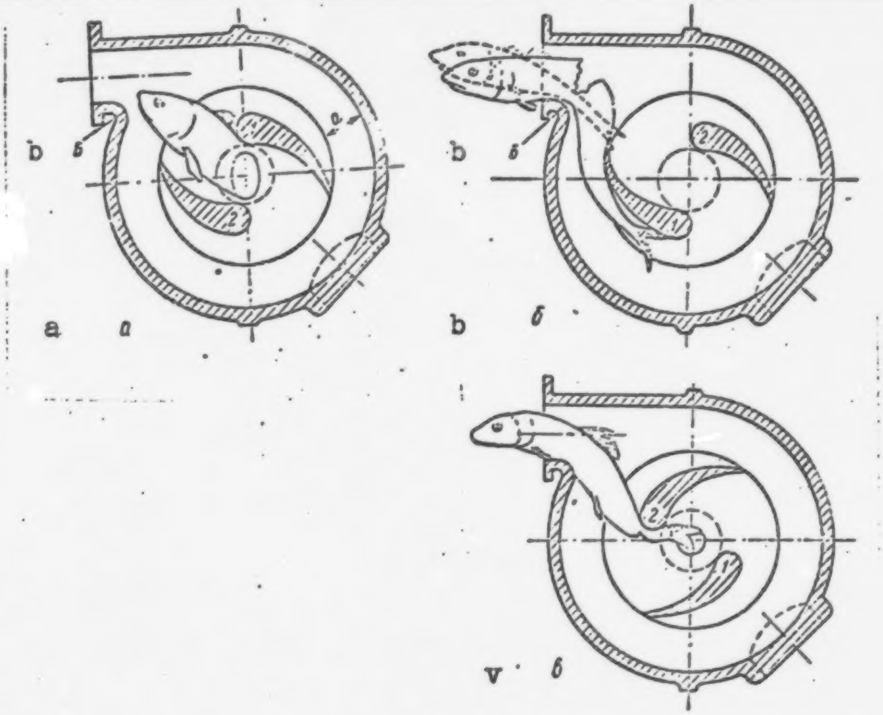


Figure 24 - Diagram of the passage of a fish through a centrifugal fish pump:

a - fish begins to emerge from wheel; b - breaking of a long fish at branch delivery conduit; v - breaking of a long fish by wheel blade.

If the fish is too long for a given fish pump, the latter will be impracticable for pumping it. Thus there exists a critical fish length. It is evident that the transverse dimensions of the fish should not exceed the amount of clearance between the wheel and the volute in the radial plane of the volute.

In order that a fish may not be crushed, it must manage to pass through the wheel in the time in which the wheel moves from the position shown in Fig. 24,a to that shown in Fig. 24, b, i.e., in the course of a half turn of the wheel. Designating the length of the fish by L_{kr}, we can write

$$\frac{L_{\kappa p}{}^{r}}{v} = \frac{\pi d_{\kappa}}{2u}, \qquad [43]$$

where v and u are the speeds of the fish and the wheel at the rim.

Hence ∠88

$$L_{\kappa p_{r}} = \frac{v}{u} \frac{1}{2} \pi d_{\kappa}. \qquad [44]$$

We shall assume that the speed of the fish is equal to the average speed of the stream in a section of the branch delivery pipe; then

$$v = \frac{Q}{F} = \frac{4Q}{\pi d^2_{mp}}, \text{ — } \bar{t}r \qquad [45]$$

where Q is the delivery of the pump in m^3/sec;

v is the speed of the stream in m/sec;

F is the area of the cross section of the delivery pipe in m^2;

d_{tr} is the diameter of the delivery pipe in metres.

On the other hand,

$$u = \frac{\pi d_{\kappa} \cdot n}{60}, \qquad [46]$$

where: d_k is the diameter of the wheel in metres;

n is the rpm of the wheel.

Substituting values v and u in formula /44/ we obtain

$$\text{tr} \quad L_{\kappa p} = \frac{4Q}{\pi d_{mp}^2} \cdot \frac{60}{\pi d_{\kappa} n} \cdot \frac{1}{2} \pi d_{\kappa} = \frac{120Q}{\pi d_{mp}^2 n}. \quad \text{tr} \qquad [47]$$

The transverse size of the fish, evidently, must conform to the disparity

$$B < a, \qquad [48]$$

where: B is the greates cross section of the fish;

a is the distance from the rim of the wheel to the wall of t pump volute.

The following formula may be derived on the basis of formula /47/ for tentative calculations:

$$\text{tr} \quad d_{mp} = \sqrt{\frac{120Q}{\pi L_{\kappa p} n}}. \qquad [49]$$

We shall express the critical length of the fish by the elements of the fish pump itself, the condition being the safety of the fish. The fish will be safe from the moment that it leaves the wheel. At that moment, part of the length of the fish, equal to the amount of clearance a between the wheel and the volute, will still remain in the volute of the fish pump.

Thus the fish should move a distance of $L_{kr} - a$ at a speed of s_2 (the net [resultant] speed of the stream leaving the fish pump wheel) during the time of half a turn of a wheel turning with a speed

$$u = \frac{\pi d_\kappa n}{60}.$$

Equating in time, we have /89

kr

s

$$\frac{L_{\kappa p} - a}{c_2} = \frac{\frac{\pi d_\kappa}{2}}{u_2}, \qquad [50]$$

whence

s

kr

$$L_{\kappa p} = \frac{\pi d_\kappa c_2}{2u_2} + a.$$

Since $s_2 = u_2\ 0.8$ (see further), then

kr

$$L_{\kappa p} \frac{\pi d_\kappa 0,8u_2}{2u_2} + a = 1,25\, d_\kappa + a; \qquad [51]$$

$$d_\kappa = \frac{L_{\kappa p} - a}{1,25} = 0,8(L_{\kappa p} - a). \qquad [52]$$

In commercial ichthylogical practice there exist several methods of measuring fish length; for example, the measurement of commercial length from the centre of the eye to the end of the last rays on the anal (tail) fin is very widespread.

For calculating the limit of applicability we shall use the zoological length of the fish, measured from the end of the snout to the bifurcation of the tail fin.

The Working Process of a Fish Pump

The working process of a fish pump differs from that of a centrifugal pump in that in a centrifugal fish pump a working mixture of fish and water that is non-uniform in its composition is transferred.

/The main assumption in our examination of the working process of a fish pump will be the fact that in a pump a fish moves in a stream of water at the speed of the stream itself.

A formula must be derived for the operating conditions of a fish pump under which the fish, in passing through the pump, will not be injured by striking some obstacle. In this case, crushing of the fish originates as a result of a reserve of energy in the fish itself, which has a certain mass and moves at a certain speed.

The kinetic energy of the blow by which a fish may be crushed is expressed by the formula

$$\text{kr} \longrightarrow T_{\kappa p} = \frac{m_p \cdot c_{\kappa p}^2}{2} = \frac{G_p \cdot c_{\kappa p}^2}{2g} \text{— s}, \qquad [53]$$

where: m_r is the mass of the fish in kg sec^2/m;

G_r is the weight of the fish in kg;

s_{kr} is the speed at which the fish comes off the wheel of ∠90 the fish pump, in m/sec;

g is the acceleration of the force of gravity, equal to 9.81 m/sec^2;

T_{kr} is the kinetic energy or work of crushing the fish, in kilogram-metres.

The speed at which the fish leaves the wheel is the value resulting from two speeds (see Fig. 21).

$$\bar{c}_2 = \bar{u}_2 + \bar{w}_2,.. \qquad |5$$

where: c_2 is the absolute speed of the stream;

u_2 is the peripheral speed of the stream on the rim of the wheel, and tangential to the rim;

w_2 is the relative speed of movement of the stream along the blade of the wheel and tangential to the blade itself;

$$u_2 = \frac{\pi d_k n}{60} \text{ м/сек,—— sec}$$

where: d_k is the diameter of the wheel of the fish pump in metres;

n is the rpm of the wheel.

The relative speed w_2 when the stream comes off the wheel (the average through the cross section of the wheel channel) is expressed by :

$$w_2 = \frac{Q}{F} \text{ м/сек,—— sec} \qquad |55|$$

where: Q is the delivery created by the fish pump, in m^3/sec;

F is the area of the outgoing cross section of the wheel channel, in m^2.

Let us assume that the value of the absolute speed s_{kr} alters negligibly from the action of the relative speed u_{kr}. This change can be allowed for by the factor K_u, which we shall call the reduction factor. Ordinarily for fish pumps

$$u \text{———} K_y = \frac{c_2}{u_2} = 0,8.$$

Let us examine the changes in the reduction factor K_u when the operating conditions of the pumps are altered.

$$\underset{u}{K_y} = \frac{\overset{s}{c_2}}{u_2} = \frac{\sqrt{u_2^2 + w_2^2 - 2u_2 w_2 \cos\beta_2}}{u_2} =$$

$$= \sqrt{\frac{u_2^2}{u_2^2} + \frac{w_2^2}{u_2^2} - \frac{2u_2 w_2 \cos\beta_2}{u^2}} = \sqrt{1 - 2\frac{w_2}{u_2}\cos\beta_2 + \left(\frac{w_2}{u_2}\right)^2}.$$

Since actually $\cos\beta_2 = 0{,}95 \cong 1$, then

$$K_y = \sqrt{\left(\frac{w_2}{u_2} - 1\right)^2} = \frac{w_2}{u_2} - 1 = \frac{Q\,60}{F\pi d_k n} - 1. \qquad [56]$$

Since the delivery is directly proportional to the number of revolutions of the wheel (see formula [37]), then /91

$$Q_2 = Q_1 \frac{n_2}{n_1},$$

where: Q_1 and Q_2 represent the discharge;

n_1 and n_2 represent the number of revolutions of the wheel under a given set of operating conditions.

Let us compare the reduction factors K_{u1} and K_{u2} under two sets of operating conditions.

$$K_{y_1} = \frac{60\,Q_1}{\pi d_k n_1 F} - 1;$$

$$\underset{u}{K_{y_2}} = \frac{60\,Q_2}{\pi d_k n_2 F} - 1 = \frac{60}{\pi d_k F} \cdot \frac{Q_1 \frac{n_2}{n_1}}{n_2} - 1 = \frac{60\,Q_1}{\pi d_k n_1 F} - 1 = K_{y_1}.$$

Thus when the operating conditions of the pump change, the reduction factor K_u remains constant

$$\underset{u}{K_y} = \text{const}. \qquad [57]$$

The invariability of K_u upon a change in operating conditions enables us to introduce this factor into general expressions of the speed s_{kr}. Having made the appropriate substitutions, we obtain

$$\underset{r}{T_{\kappa p}} = \frac{G_p c_{\kappa p}^2}{2g} = \frac{G_p}{2g}(K_y u_{\kappa p})^2 = \frac{G_p}{2g}\left(\frac{K_y \pi d_\kappa n_{\kappa p}}{60}\right)^2,$$

whence

$$n_{\kappa p}^2 = \frac{2g\,T_{\kappa p}\,60^2}{G_p (K_y \pi d_\kappa)^2};$$

$$n_{\kappa p} = \frac{60\sqrt{2 \cdot 9{,}81}}{0{,}8 \cdot 3{,}14} \cdot \frac{1}{d_\kappa}\sqrt{\frac{T_{\kappa p}}{G_p}};$$

$$\underset{r}{n_{\kappa p}} = 103\,\frac{1}{d_\kappa}\sqrt{\frac{T_{\kappa p}}{G_p}}. \qquad [58]$$

Let us examine the conditions for the safety of the fish in relation to the pressure head developed by the fish pump. For this purpose we shall consider the basic expression of the pressure head developed by the fish pump (see formula [35b])

$$H_н = \eta_h K \frac{u_2 c_2 \cos\alpha_2}{g}.$$

We shall express the relative speed u_2 by the absolute c_2 and, having assigned to the latter a critical value, we shall express it by the critical work of crushing the fish

$$H_{н\,кр.} = \eta_h K \frac{\cos\alpha_2}{g}\cdot\frac{c_{кр}}{0,8}\cdot c_{кр} = \eta_h K \frac{\cos\alpha_2}{0,8g} c^2_{кр} = \eta_h K \frac{\cos\alpha_2}{0,8g}\cdot\frac{2T_{кр}}{G_p}. \qquad [59$$

r

When we have calculated the numerical values of the coefficients, we get the expression of the critical pressure head of the fish pump 102

$$H_{н\,кр} = 1,05\frac{T_{кр}}{G_p}. \qquad [59a]$$

r

Table 7

The Limits of Applicability and the Operating Conditions of Centrifugal Fish Pumps

Fish pump	Diameter of wheel d_k, in m	Maximum clearance a, in m	Limit of applicability		Name of fish being pumped (bulk)
			L_{kr}, in m	B_{kr}, in m	
4NF	0,300	0,080	0,455	0,075	Anchovy, sprat, and goby
6NF	0,450	0,125	0,690	0,120	Herring, roach and Baltic herring
8NF	0,540	0,160	0,800	0,155	Black-backed shad, bream and pike-perch
RB-100	0,300	0,110	0,455	0,105	Anchovy, sprat, goby, small herring and Baltic herring
RB-150	0,450	0,135	0,690	0,130	Herring, roach and large Baltic herring
RB-200	0,595	0,195	0,940	0,190	Pike-perch, bream and chum

Table 7 (continuation)

Critical rpm of wheel n_{kr}	Maximum pressure head $H_{m_{kr}}$, in metres of a column of water	Remarks
1170	12,0	
780	12,0	
510/635	7,5/12	Bream and pike-perch, with the exception of select and large specimens
1170	12,0	
780	12,0	
460	7,5	

The latter expression is not a direct, but rather an indirect, characteristic of fish pump operating conditions that are safe for fish, since a fish can be crushed not from stress due to the pressure head developed by the fish pump, but rather from striking the wall of the housing, i.e., as a result of too large a number of revolutions of the wheel of the centrifugal fish pump. /93

Table 7 has been prepared on the basis of derived formulas for the limits of applicability and the critical number of revolutions [of the wheels] of centrifugal fish pumps. This table gives the results of calculations from these formulas for various fish and different makes of centrifugal fish pumps used both previously and at the present time.

The data in the table agree closely with the data of numerous experiments on pumping fish with fish pumps of different diameters.

5. Centrifugal Fish Pump Designs

Pumps of Make NF From the Kalinin Plant

The first centrifugal fish pumps produced by the USSR are represented by sewage pumps of makes 4NF and 8NF (see Fig. 25). They are intended for pumping heavily contaminated liquids and have been designed for the free passage through them of coarse impurities in the liquid that is being pumped. The operating wheel

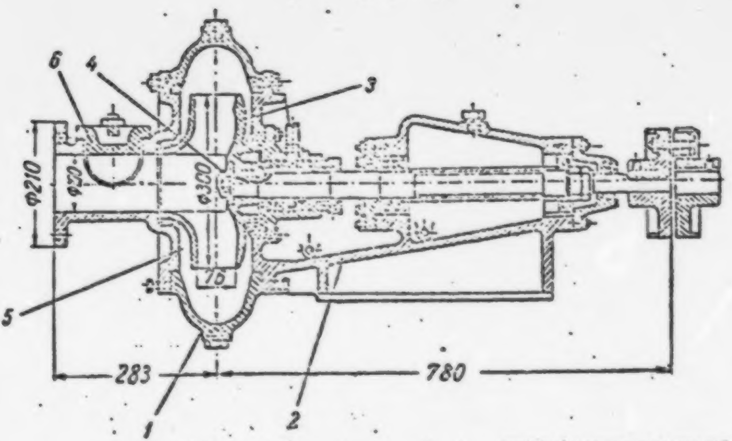


Figure 25 - General view of 4NF pump (Kalinin Plant): 1 - housing; 2 - frame; 3 - operating wheel; 4 - nut; 5 - clearance between wheel and housing; 6 - inspection hole on branch intake pipe

---

with two blades, is fastened to the shaft on a key in a cantilever arrangement with an ordinary six-sided nut. The pump housing is bounded in a vertical plane by two covers. The forward cover is cast together with the branch intake pipe, and the rear cover, with the pump frame.

The pump housing is in the shape of a volute. The volute is a diffuser and terminates in a branch delivery pipe. A delivery conduit is fastened to the flange of the branch delivery pipe. On the top and bottom of the housing are openings, sealed with plugs, for discharging air and dirt. 104

The housing of the NF pump is supplied with an inspection hole. The branch intake pipe has the same kind of inspection hole. The latter pipe terminates in a flange for attaching an intake pipe or a rigid hose. There are large clearances between the wheel of the pump and the inner surface of its housing and covers.

A stuffing box device with maze packing and a hydraulic seal is fastened on bolts to the rear cover of the housing of the NF pump.

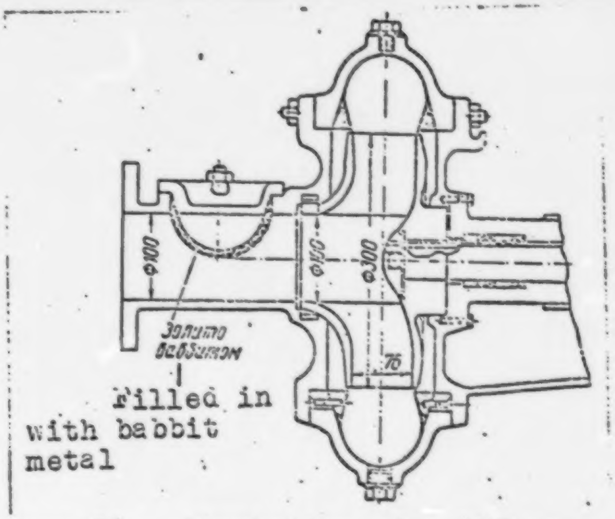


Figure 26 - Adaptation of a 4NF pump for pumping fish.

The drive cantilever end of the shaft is equipped with a pulley or a clutch.

NF pumps are not designed specially for pumping fish. The presence, in the inner cavity of the pump, of a six-sided, rapidly revolving nut, of recesses with sharp edges on the inner surfaces of the pump housing at the places where they join the lids of the inspection holes, and the large clearances between the wheel and the volute - all create conditions for mechanical injury to fish that is pumped. Another source of such injury includes burrs and roughness on the inner surfaces of the pump and its wheel.

The first experiments on using NF pumps as fish pumps showed that certain small but highly essential changes would have to be made in their inner cavities. In order to adapt the NF pump to pumping fish, it was necessary to file all burrs and roughness in the inner cavity of the pump and to fill in with babbit metal the recesses in the areas where the inspection holes came into contact with the inner surfaces. It was also necessary to replace the six-sided nut with a hemispherical nut and to close the clearance between the wheel and the pump housing with a special ring.

NF pumps adapted in this way (see Fig. 26), during further tests as fish pumps, gave satisfactory results. A 4NF pump was used for pumping anchovy in the Kerch region, ∠95 and an 8NF pump, for pumping herring (Caspian shad) in Dagestan.

NF pumps are not presently used as fish pumps and have been universally replaced by special fish pumps of the RB type. At fishing industry enterprises where they have been retained, NF pumps are used as priming pumps (see Chapter VII).

Fish Pumps of Type RB

Defects contributing to mechanical injury to fish have, in the design of fish pumps of type RB (see Fig. 27), been taken into consideration and to a large extent eliminated.

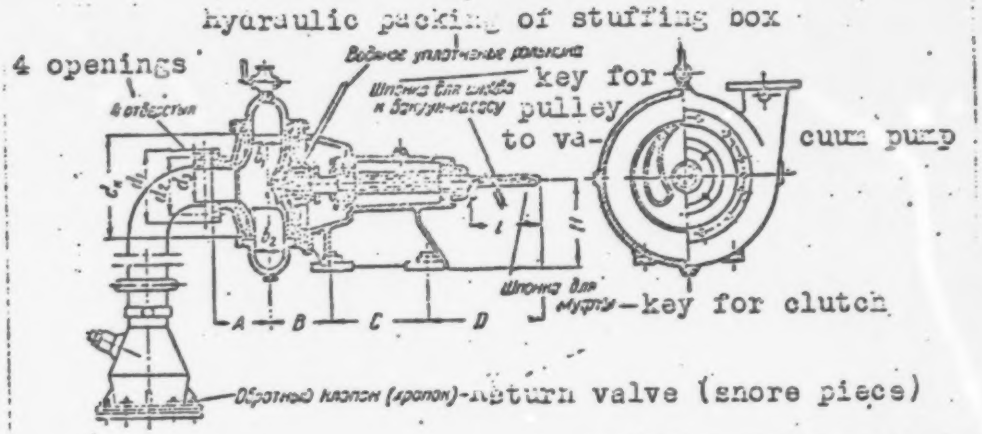

hydraulic packing of stuffing box
Водяное уплотнение сальника
4 openings
4 отверстия
Шпонка для шкива к вакуум-насосу
key for pulley to vacuum pump
$d_н$
d_1
d_2
b_2
l
A
B
C
D
Шпонка для муфты—key for clutch
Обратный клапан (храпок)-return valve (snore piece)

Figure 27 - RB fish pump.

The operating wheel of the RB fish pump has two streamlined blades and wide inner channels. The shape of the blades at the part where they taper provides the best conditions for the movement of fish off the operating wheel. The wheel of the RB pump is fastened to the shaft with a streamlined nut. The main force from the shaft is transmitted to the wheel through a knife-edge key, while the streamlined nut secures the axial position of the wheel on the shaft.

The housing of the RB fish pump is cast in the form of a volute with a dilating diffuser terminating in a branch delivery pipe. To the housing are fastened, on bolts, a forward cover with a branch intake pipe, and a rear cover, which is also fastened to the frame. The inner surfaces in the fish pump are thoroughly smoothed and painted. In contrast to the NF pump, the RB fish pump has no inspection holes whose covers /96 previously represented an area where fish were damaged[1].

---

[1] Personnel involved in operations have recently been insisting on the installation of an inspection hole for fish pumps transferring small fish, in order to observe the density of the mixture in the pump housing and to inspect the housing without removing the cover.

A feature of the RB fish pump is the junction of the rim of the operating wheel and the housing with an extremely small clearance, which prevents even the smallest fish from getting in between the wheel and the housing.

The housing of the RB fish pump can have eight different positions together with the branch delivery pipe, in conformity with the number of bolts fastening the rear cover to the frame. This results in a certain convenience in assembly and in many cases permits an elbow on the delivery conduit to be dispensed with.

In the inner part of the housing there is an opening, closed with a threaded plug, for discharging air from the inner cavity of the pump and for priming it. Four nipples have been cast onto the fish pump housing for installing such openings.

The frame of the RB fish pump has a lubricating chamber provided with an opening for pouring in oil, and an oil level indicator. The stuffing box installation of the RB fish pump is similar to that of the NF pump and has maze packing and a hydraulic seal created using the water that enters the stuffing box under pressure through a tube from the conduit or from the fish pump itself, if it is pumping a working mixture that is not heavily contaminated with scale.

The drive end of the RB-100 fish pump shaft has two key beds for two pulleys. One of the pulleys serves to operate the fish pump from a motor, while the other is for driving a water circulating* vacuum pump through the fish pump. The vacuum pump draws off air from the inner cavity of the fish pump and into it [the cavity] draws liquid or a working mixture through an intake hose, which permits a return valve (snore piece) on the end of the intake hose to be dispensed with. In fish pumps of the remaining model sizes the drive end of the shaft is of the length that is required for the fitting on of only one pulley.

The pump is fastened to its base with four bolts, openings for which are in the supporting part of the frame.

RB fish pumps are manufactured in four model sizes (RB-100, RB-150, RB-200 and RB-250) by the Kandalaksha Machine Building Plant.

---

* Translator's note. The modifier "water-circulating" is a suggested rendition of the Russian vodokol'tsevoi. for which no other suitable equivalent is available. The Russian term is derived from the words voda (water) and kol'tsevoi (annular, circular, circumferential, cyclic).

RB-100 fish pumps are widely used for pumping small fish (anchovy, tiulka, and sprat), and are employed in the Azov-Black Sea and Caspian Basins.

RB-150 pumps are used for pumping Baltic herring in the Baltic Basin. RB-200 fish pumps are widely employed in pumping herring in the Far East.. RB-250 fish pumps are in /97
use for pumping large fish of the salmon family also in the Far East.

[Please ignore space; text is continued on next page.]

Table 8

Structural Dimensions of RB Centrifugal Fish Pumps

(for symbols see Fig. 27)

Model Size	d_1	d_2	d_a	d_K	b_1	b_2	A
RB РБ-100	210	170	100	300	80	85	160
РБ-150	265	225	150	450	120	128	230
РБ-200	320	280	200	595	160	170	300
РБ-250	425	370	250	745	2 0	210	370

Table 8 (continuation)

Model Size	B	C	D	Г	H	Weight in kg
RB РБ-100	180	275	330	200	250	151
РБ-150	265	410	383	250	375	436
РБ-200	350	550	450	290	500	963
РБ-250	436	720	234	140	690	1750

RB fish pumps combined with engines, fittings and auxiliary equipment are manufactured in the form of fish pumping installations designated as make RBU. The Kandalaksha Machine Plant manufactures fish pumping units of three types: the RBU-100, the RBU-200 and the RBU-250, with which are included the appropriate fish pumps. Industry manufactures no units that include the RB-150 fish pump.

The RBU-100 fish pumping unit (see Fig. 28) consists of an RB-100 fish pump mounted on a metal frame with a 4.5-kw electric motor, to which it is connected with a reducing gear. On the same frame is mounted a BKF manual pump, with which the fish pump and its intake hose are primed with water.

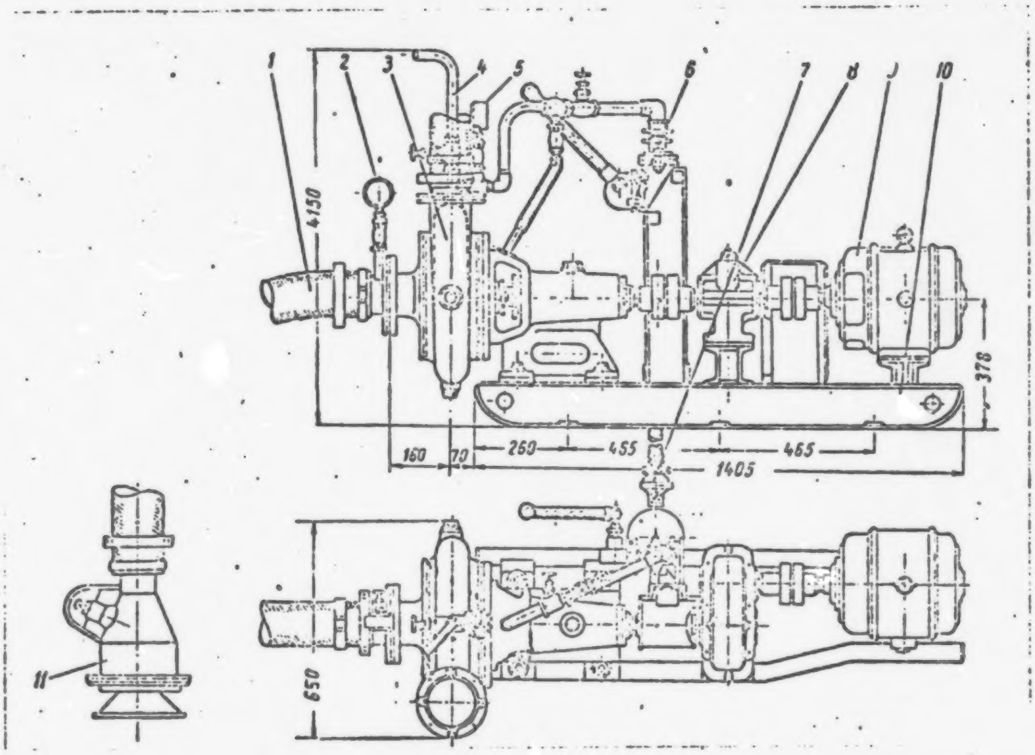

1
2
3
4
5
6
7
8
9
10
11
1150
378
160
70
260
455
465
1405
650

Figure 28 - A complete RBU-100 fish-pumping unit:

1 - intake hose; 2 - vacuum gauge; 3 - RB-100 fish pump;
4 - bypass pipe; 5 - pressure gauge; 6 - BKF manual pump;
7 - intake valve of manual pump; 8 - reducing gear;
9 - electric motor; 10 - frame of fish-pumping unit;
11 - normal intake valve of fish pump.

The unit is designed for discharging small fish, waste, and contaminated liquids and can be mounted both on shore and on a ship. 109

Technical Description of the RBU-100 Fish-Pumping Unit

Discharge of fish in tons per hour	12 to 18
Number of revolutions per minute:	
Mark I	852
Mark II	730
Recommended pressure head, in metres	8 to 9
Electric motor:	
power in kw	4.5
rpm	1,460
Weight of unit in kg:	
without water	411
with water	480
Length of time required to prime system with water by BKF manual pump in minutes	5

The RBU-200 (see Fig. 29a) and RBU-250 (see Fig. 29b) fish-pumping units are made in one type and differ from each other only in the model size of the fish pump that is used, as well in the arrangement of the gasoline tank. They are mounted on a metal frame and are operated by a 90-hp ZIS-120 engine; a GAZ-51 engine is also used.

Transmission is effected with a clutch coupling and a gear box from a ZIS-150 automobile and a compensating clutch on the shaft of the fish pump.

Besides the fish pump, with its hoses and snore piece, and the engine, the unit includes a two-inch centrifugal TsN-6 circulating pump for priming the fish pump with water, cooling the engine and for pumping water from a kungas if the unit is installed on board ship. The TsN-6 pump is operated from a ZIS-120 engine by a V-belt* drive. The unit also includes a storage battery for starting the engine, a gasoline tank and a cooling water tank (fresh cooling water is used, in the event that the unit operates at sea, in order to avoid cooling the engine with salt water).

In the RBU-200 fish-pumping unit the gasoline tank is installed above the pump frame, and in the RBU-250, beside the ZIS-120 engine. The latter arrangement results from an attempt to decrease the metacentric height when arranging the RBU-250 unit on a kungas. If the gasoline tank were located above the fish pump, given the latter's increased weight and the considerable height of its frame, the stability of the kungas would be greatly reduced.

---

* Translator's note. "V-belt" is believed to be a probable equivalent of the Russian klinoremennyi, for which no other suitable equivalent is available.

Where these fish-pumping units are to be located afloat, in the interests of safety and stability the vessel employed should be a kungas with a cargo capacity of no less than 20 tons.

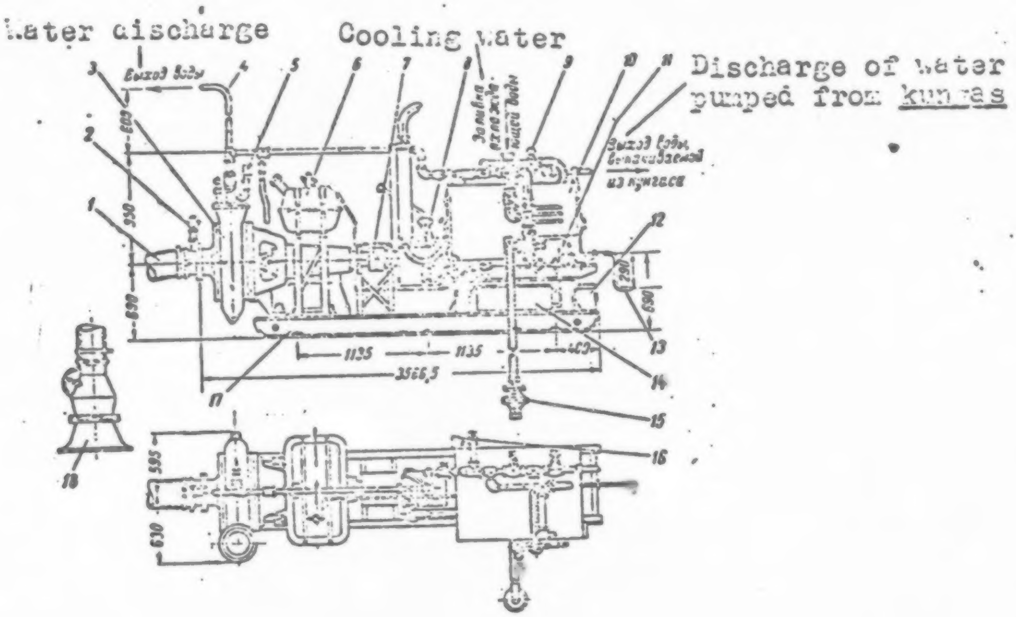

Water discharge
Cooling water
Discharge of water pumped from kungas
Выход воды
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
1135
1135
3566,5
290
630
595

Figure 29 a - Complete RBU-200 fish-pumping unit:
1 - intake hose; 2 - vacuum gauge; RB-200 fish pump;
4 - bypass pipe; 5 - pressure gauge; 6 - gasoline tank;
7 - compensating clutch; 8 - gear box; 9 - air cock;
10 - ZIS-120 engine; 11 - TsN-6 centrifugal pump;
12 - storage battery; 13 - starting crank; 14 - water tank;
15 - intake valve with screen of TsN-6 pump; 16 - pressure gauge for engine; 17 - frame of fish-pumping unit;
18 - normal RB-200 snore piece.

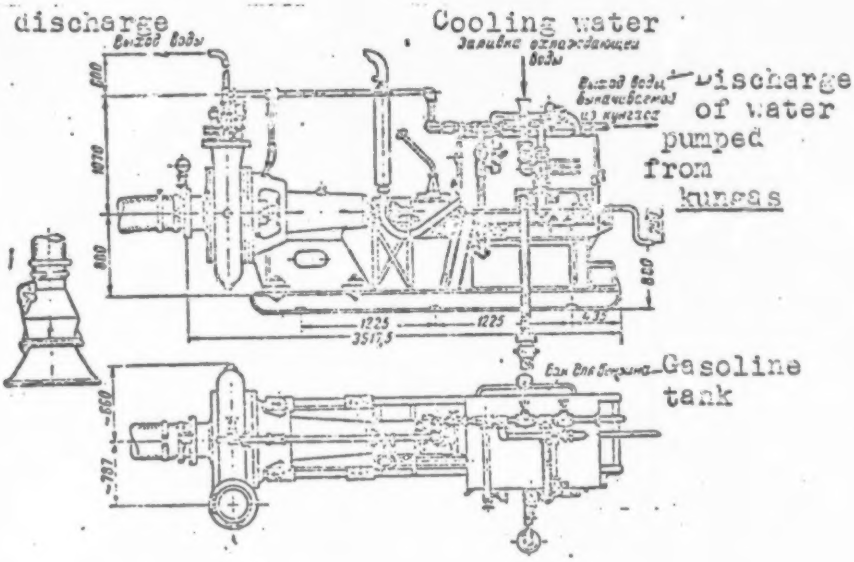

Water discharge
Выход воды
Cooling water
Заливка охлаждающей воды
Выход воды выкачиваемой из кунгаса
Discharge of water pumped from kungas
Gasoline tank
600
1070
800
850
1225
1225
435
3517,5
660
787

Figure 29b - Complete RBU-250 fish-pumping unit.

Technical Description of RBU-200 and RBU-250 /101

Fish-Pumping Units

	RBU-200	RBU-250
Discharge of fish in tons per hour	25 to 35	35 to 50
Recommended rpm	580	400
Recommended pressure head, in metres	8 to 10	9 to 11
Engine:		
horsepower	90	90
rpm's	2,700	2,700
Weight of unit in kilograms:		
without water or gasoline	2,129	3,055
with water, gasoline and oil	2,749	3,865

The mobile RBU-100 fish-pumping unit with a vacuum pump, which has been engineered by the State Institute for the Planning of Enterprises and Machinery of the Fishing Industry /Giprorybprom/ from a VNIRO plan (see Fig. 30), consists of a rotatable frame on which the following have been mounted: an RB-100 fish pump with a reduction gear and an electric motor; a vacuum pump with an electric motor; a pouring tank; a return valve on the branch delivery pipe of the fish pump; utility conduits; starters; a crane arm with a span of 2.5 metres for raising the hose, and a hand winch.

The mobile unit is mounted on a four-wheeled trolley (2,400 x 2,100 mm) with a pull handle. The weight of the trolley is 950 kg.

The unit is designed for unloading salted fish from tubs. The trolley can be moved from tub to tub. When the wheels have been removed from the trolley frame, the unit can be mounted on wharves for unloading fresh fish from ships' holds.

A Fish Pump with a Pear-Shaped Volute

M.I. Antipov, an engineer of the Chief Directorate of the Fishing Industry of the Amur Basin* [Glavamurrybprom] has replaced the flat volute of the usual design on the RB-250 centrifugal fish pump with a pear-shaped volute, which provides the safest conditions for large fish that are transshipped, for example, Amur chum.

The volute is pear-shaped (see Fig. 31) and has a steel ring 7, around the periphery of which are openings for fastening the volute with bolts to the housing of a standard RB-250 fish pump.

To the ring 7 is welded an outer cone made of 4-mm sheet steel. Towards its peak the cone smoothly changes into a cylinder 250 mm in diameter and terminates in a flange 8 for attaching the flanged branch pipe of the delivery conduit.

The inner cone consists of a steel ring 4, to the outer edge of which is welded a cone 9, made of 4-mm sheet steel; to the inner edge is welded a small cone 10, to which in turn is welded

---

* Translator's note. A suggested expansion of the Russian term that follows immediately in brackets.

the ring of the branch intake pipe 5. Again, to this ring is welded the branch intake pipe 3, bent into an elbow and cutting through the walls of the inner and outer cones of the pear-shaped volute. The branch intake pipe 3, which is 250 mm in diameter, terminates in the flange 9, which is intended for fastening the flanged branch pipe of the fish intake conduit. The bent branch intake pipe 3 also serves to fasten the inner cone to the outer. A second fastening point is ∠103
the short, tubular, streamlined insertion piece 12.

In Fig. 31 dotted arrows represent the path of movement of fish from the intake pipe through the operating wheel and further into the conical annular space between the outer and inner cones.

Since the pear-shaped volute is fastened to the housing of a standard RB-250 fish pump, the alteration of the fish pump itself amounts to no more than replacing the ordinary volute with a pear-shaped volute.

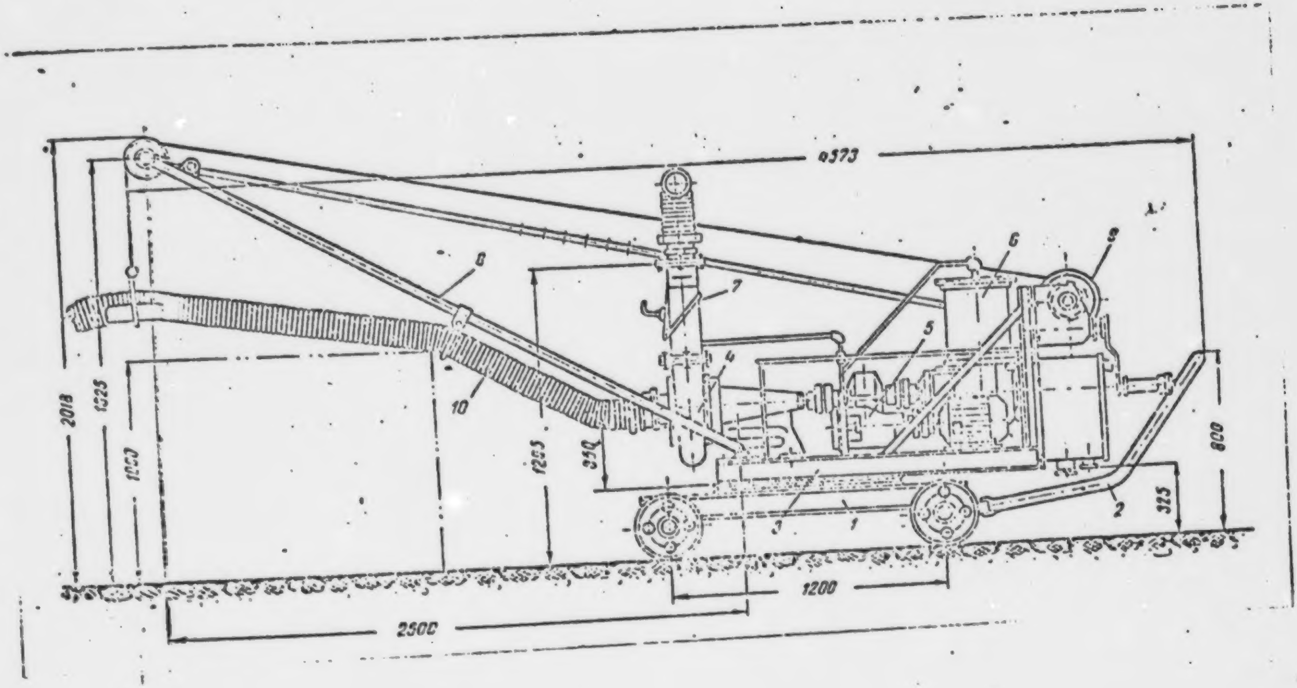

4373
2018
1525
1000
1265
330
800
325
1200
2500
1
2
3
4
5
6
7
8
9
10

Figure 30 - Mobile RBU-100 unit with vacuum pump:

1 - four-wheeled trolley; 2 - pull handle; 3 - rotatable frame; 4 - RB-100 fish pump; 5 - vacuum pump; 6 - pouring tank; 7 - return valve on branch delivery pipe of fish pump; 8 - crane arm; 9 - hand winch; 10 - intake hose.

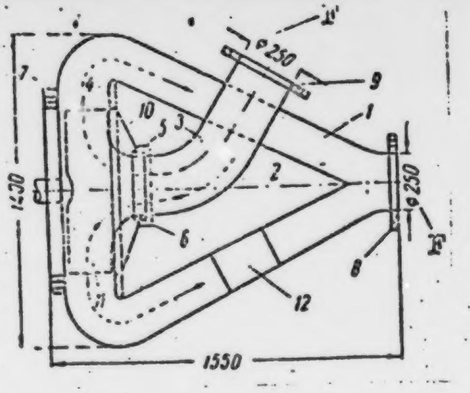


Figure 31 - Diagram of a pear-shaped volute:
1 - outer cone; 2 - inner cone; 3 - branch intake pipe;
4 - ring of inner cone; 5 - ring of branch intake pipe;
6 - inner ring of branch intake pipe; 7 - ring for fastening outer cone to frame; 8 - supporting flange; 9 - intake flange;
10 - connecting cone; 11 - RB -250 operating wheel;
12 - insertion piece for fastening cones.

The installation of a pear-shaped volute excludes the possibility of pinching the fish, since the latter can come off the operating wheel of the fish pump and be directed towards the branch delivery pipe at any point on the periphery of the operating wheel.

RB-250 fish-pumping units with pear-shaped volutes have been tested in pumping large chum (average weight 5 kg, length 720 mm) at fishing enterprises located in the estuary of the Amur River.

The full height to which the fish were raised was 6.9 m, and the concentration of the fish mixture varied from 1:6 to 1:8; the rpm of the operating wheel of the fish pump was 270.

No injury was observed in any of the fish that had been pumped.

Thus fish pumps with pear-shaped volutes can be used in pumping large fish weighing in excess of 3 kg, in particular Okhotsk, Kamchatka and Amur chum.

6. Improving Fish Pump Design

/104

A fish pump (see Fig. 32) made of transparent block organic glass has been created in the VNIRO Mechanization Laboratory (B.N. Miller) for work on improving the housing (volute) and the operating wheel of the centrifugal fish pump; the necessary research has been carried out.

In order to create the same operating conditions in the transparent fish pump as in a cast-iron (standard) fish pump, the housing and operating wheel of the RB-100 transparent fish pump were made with all of the internal dimensions and all the contours of the operating wheel and housing of the RB-100 cast-iron fish pump. The outer contours of the housing and the operating wheel, however,

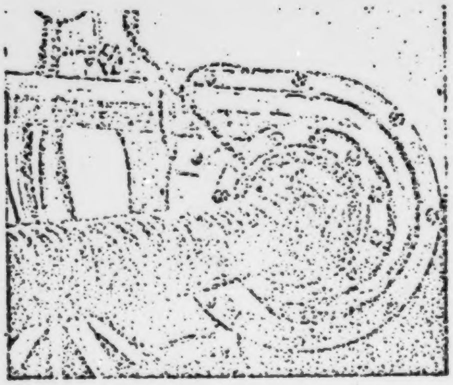


Figure 32 - General view of fish pump of transparent organic glass.

allowing for the fact that organic glass is less sturdy, were somewhat enlarged (see Figs. 33 and 34). The frame for the transparent housing and operating wheel of the fish pump, and its drive element, were taken from a standard fish pump. Three sets of detachable blades were prepared in order to demonstrate the effect of the shape of the operating wheel blades on the process of pumping a mixture of fish and water.

The blades of the first set were of the same design as those of standard RB-100 fish pumps (the outer radius of curvature was 148 mm, and the inner, 125 mm).

The blades of the second set had the same configuration as those of the first set, but their terminal part was more elongated. The blades of the third set were more curved; the outer radius of curvature was 128 mm, and the inner, 85 mm.

The fish pump was mounted on the wharf of the Kerch Refrigeration Plant, where all of the research was carried out.

Visual observations were made for research into the process by which a mixture passes through a fish pump, and high-speed (high-frequency) motion pictures were taken for investigating the process involved in the passage of the following: pure water, a mixture of fish and water (anchovy and goby), and a mixture of water and sawdust. The mixture of water and sawdust was passed through in order to determine the lines of flow and at the same time to clean the inner surfaces of the operating wheel and the volute of the transparent fish pump. ∠106

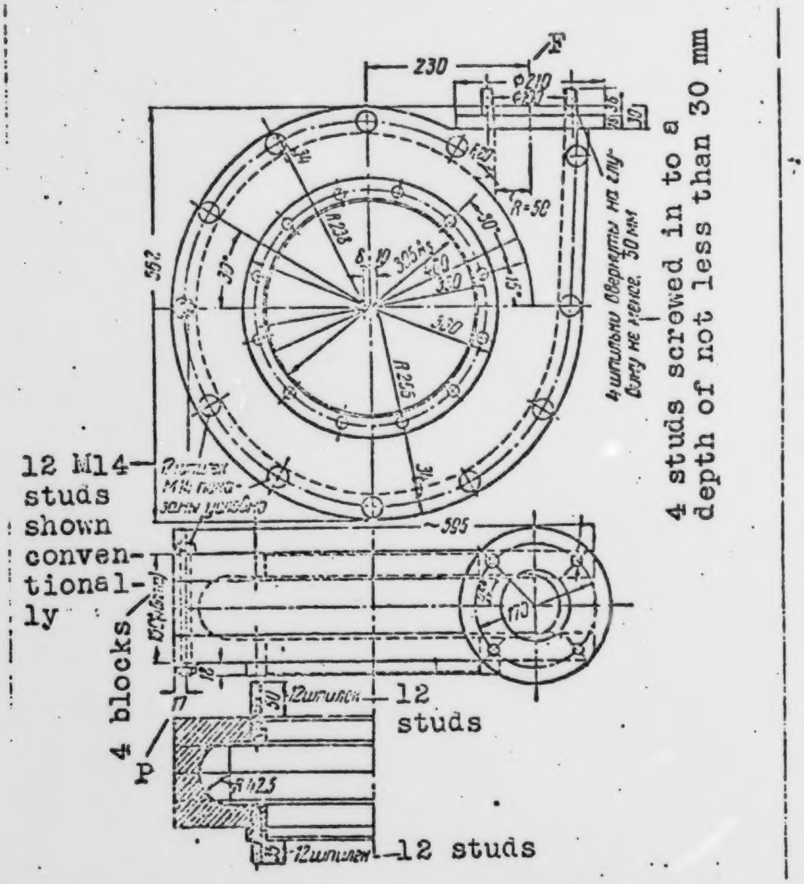

230
F
Ø210
352
R233
R255
R=50
305
400
330
320
~595
170
R425
12 M14 studs shown conventionally
Шпильки M14 показаны условно
4 studs screwed in to a depth of not less than 30 mm
4 шпильки ввернуть на глубину не менее 30 мм
4 blocks
P
12 шпилек
12 studs
12 studs

Figure 33 - The housing of a fish pump of transparent organic glass.

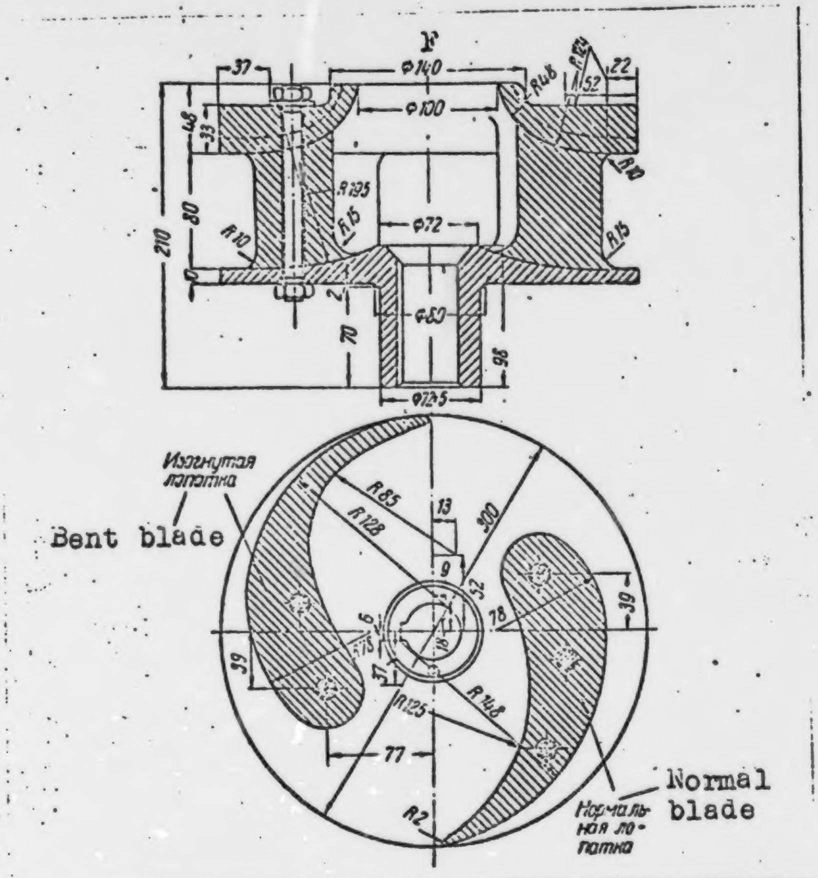

F
37
Φ140
Φ100
R48
52
22
48
33
R135
R15
R10
Φ72
210
80
10
2
Φ80
70
96
Φ72.5
Изогнутая лопатка
Bent blade
R85
R128
13
300
9
32
78
39
6
37
39
R125
R148
77
R2
Нормальная лопатка
Normal blade

Figure 34 - The operating wheel of a fish pump of transparent organic glass.

Visual Observations of the Passage of a Stream Through a Fish Pump

The observations that we carried out permitted us first of all to establish that the stream in the circular cavity of the volute, forks: part is directed immediately into the branch delivery pipe and part continues to revolve together with the operating wheel.

If we assume that the volume of the stream is directly proportional to the cross section of the branch delivery pipe and to the cross section of the circular cavity, which are 77.5 and 56 cm^2 respectively, only 58% of the total volume of the stream is directed into the branch delivery pipe, while /107 42% of the volume continues to revolve together with the operating wheel (see Fig. 35).

This phenomenon was initially established during testing operation of the transparent fish pump with pure water. Here on the "tongue" - a projection between the branch delivery pipe and the circular cavity of the volute - bubbles formed, resembling a constant effervescence.

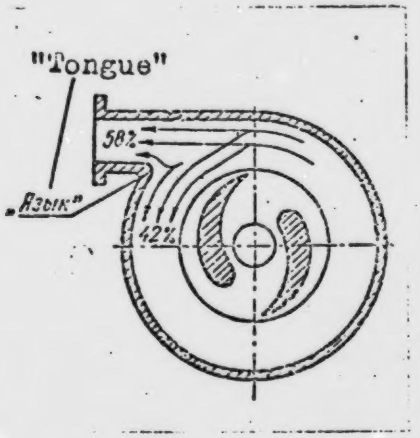


Figure 35 - Bifurcation of the stream in the housing of the fish pump

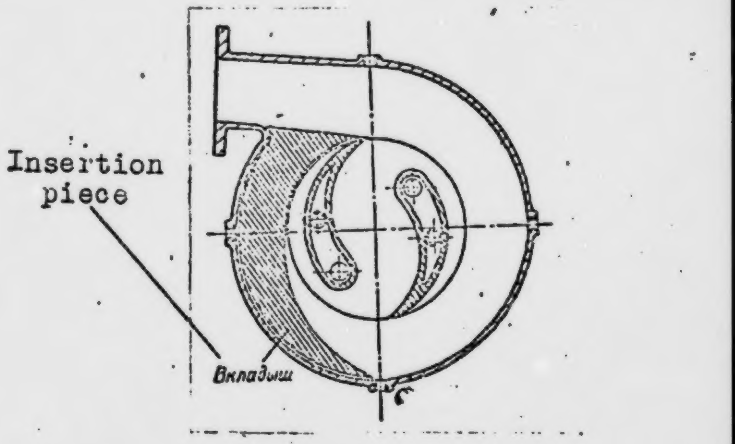


Figure 36 - Installation of an insertion piece in the volute of an RB-100 fish pump.

After the passage of pure water was observed, observations were carried out on the passage through the transparent volute of a mixture of fish and water: anchovies and water in a ratio of 1:3 and goby and water in a ratio of 1:8. It was clearly seen how some of the fish moved directly into the branch delivery pipe, others swerved down into the circular cavity of the volute and continued to revolve, while still other fish struck the "tongue", rubbed against it and were then carried away by one or another stream. Thus it became evident that the "tongue" was the very place were the fish could suffer fairly extensive injury, right up to having their bodies broken.

When a mixture of water and sawdust passed through the transparent volute of the fish pump, phenomena similar to those described above were observed.

In order to eliminate the bifurcation of the stream, an insertion piece of a soft species of wood (see Fig.36), which shut off the entrance to the circular cavity, was prepared and installed in this cavity.

Observations of the passage of a stream in the transparent fish pump demonstrated that the insertion piece completely eliminated the bifurcation of the stream and secured the smooth passage of the fish at the end of the insertion piece adjoining the operating wheel. At the same time, no eddies of the stream were observed at the junction point of the insertion piece and the operating wheel.

In the course of observation we demonstrated the harmful effect of the entry (inrush) of air when the return valve on the intake hose was in an incorrect position; we also established the necessity for priming the fish pump fully with water before starting. /108

If air burst into a normally operating pump through the intake hose, it was seen how it accumulated in the upper part of the volute. Moreover [please ignore space; text continued on next page] , after the operation of the pump ceased, the water remaining in its housing frothed, and the fish were damaged. The same phenomenon was observed in an attempt to start the fish pump with the presence of air that had not been completely expelled from the volute. It should be noted that the entry of small quantities of air into the volute, even when the snore piece is in the correct position, occurs owing to air that is in the mixture itself. When the delivery conduit has been properly assembled, this air is usually expelled by water. If the pressure line sags in such a way that the accumulations of air do not escape from it (if a "pocket" forms), air also gradually accumulates in the upper part of the volute, and the operation of the pump is disrupted.

There was, unfortunately, no release cock in the upper part of the housing of the transparent fish pump, and the pump could be switched on only after the air had been expelled from the volute.

The harmful influence on the operation of the fish pump resulting from the entry into the volute of a mixture of non-uniform density was established in the course of observation. When a mixture that is uniform in its fish content enters a fish pump, the latter operates smoothly and without breakdowns, the stream moves evenly, and, as a result, the most favourable conditions are created for pumping fish without damaging it.

When the return valve (the snore piece) is immersed in a denser mixture, the fish enter the pump in the form of one or several "chunks", which disrupt, as it were, the stream, obstruct the inner channels of the fish pump, and noticeably reduce the speed of movement of the fish within the volute, which leads to the damage of the fish that is being pumped.

High-Speed Motion Picture Filming of the Process of the Passage of a Stream Through a Fish Pump

For the objective confirmation of the results of visual observation and in order to investigate the process of the movement of a mixture through a fish pump, high-speed motion picture filming of this process was conducted.

The filming was performed at speeds of 1,400 to 4,000 frames per second (the frame size was 7.5 x 10.4 mm); the subjects registered on the film at a speed of up to 20.5 m/sec both under natural solar illumination and under spotlights.

A black screen was installed behind the fish-pump volute for greater contrast in photographing.

Focusing was performed from an object (a small fish) secured immovably in the central plane of a vertical cross section of the volute. /109

The motion picture filming was carried out as follows. After the motion picture camera had been suitably prepared, a mixture of fish (anchovy or goby) and water in a certain proportion was made ready in a receiving and measuring vat. The quantity of fish in the mixture was determined by weight, and the amount of water, from a measuring rod set up in the tank. The intake hose of the fish pump, with a return valve at its end, was first lowered into the measuring vat. The volute of the transparent fish pump, the intake hose and the initial part of the delivery conduit were primed with water. The mixture being transferred was stirred continually.

The spotlights and the fish pump were then switched on and the filming was carried out. The visibility of the passage of the mixture of fish and water through the volute of the transparent fish pump was very good, particularly where spotlights were used for illumination, and it could be observed at what moment the stream of mixture in the fish-pump volute assumed a steady, uniform nature. Usually, from 20 to 40 seconds elapsed from the beginning of operation of the fish pump until the moment when the stream in the volute became steady.

Each subject was photographed several times with identical exposure time and speed or with minor variations of these values.

In order to establish the current lines in the fish pump, high-speed motion pictures were also taken of the process whereby a mixture of sawdust and water (in a ratio of 1:3) passed through the pump.

The mixture was prepared in a measuring vat, thoroughly stirred and pumped with the fish pump.

The processes whereby a mixture of fish and water and a mixture of sawdust and water passed through were photographed with and without and insertion piece. In addition, the processes involved in the passage of the above mixtures were photographed with the blades of the fish-pump operating wheel both conventional and bent.

Photographs were taken of a total of fifteen series of the operation of the fish pump with a mixture of anchovy and water, goby and water, and sawdust and water at two rotation speeds of the operating wheel.

In all of the filming, a timer, which produced a flash of light on the film every second, was included in the equipment.

Some Data on the Effect of the Design of a Fish Pump on its Operating Characteristics

The constructional design of the individual elements of centrifugal and fish pumps has a considerable influence on their operating characteristics.

The data of some research indicates that the performance of a pump in characteristic areas drops sharply when the number of blades is reduced.

If the performance of a pump with six blades is taken as 100%, /110 the pump's performance as the quantity of blades is decreased will be as follows:

Number of blades	Discharge, in percent	Pressure head, in percent	Efficiency, in percent
6	100.0	100.0	100.0
4	94.5	94.5	97.0
3	89.0	86.5	95.0
2	84.5	74.5	88.0

It may be seen from the above data that when the number of blades is reduced, the sharpest drop occurs in the pressure head.

It is known from the theory of the operation of centrifugal pumps that when the operating wheel revolves, increased pressure developes on the forward surfaces of the blades, and decreased pressure, on the rear surfaces. Hence a constant circulation of water takes place in the channels between the blades; moreover, the wider these channels, the more perceptible will be the circulation from the zone of increased pressure to that of decreased pressure, and the stronger will be the eddying of the stream in the channels.

In centrifugal fish pumps, where two blades are quite deliberately used in order to keep the fish that is pumped in the best of condition, it is naturally impossible to improve performance by increasing the number of blades. Thus we should bear in mind beforehand that in centrifugal fish pumps, we cannot obtain optimum performance as compared with that of ordinary pumps, and we should accept the possible development of some eddying of the stream in the channels between the blades.

On the basis of theoretical reasons for avoiding impact at the entrance and outlet of the blades, the latter should be made of equal thickness at their ingoing and outgoing ends. This, however, is correct only with inflows of a certain quantity. Moreover, when the thickness of the ingoing part of the blades is decreased, the efficiency of the pump drops somewhat and the risk is created that cavitation may appear. Therefore, it is recommended that the ingoing ends of the blades be somewhat thicker than the outgoing ends, and rounded, in order that a wider range of inflows may be used. When improving fish pumps, we can decrease somewhat the thickness of the ingoing ends of the blades as against the existing dimensions, which, however, cannot significantly improve the performance of the pumps.

The blade curvature adopted in the centrifugal fish pump has corresponded to an outer radius of 140 mm and an inner radius of 120 mm.

In tests of blades of different curvature in the transparent fish pump, it was established that with a greater blade curvature (where the outer radius of curvature was 128 mm, and the inner radius, 85 mm) the efficiency increased/ [sic] where the inflow was reduced from 30 to 25 litres per second, and the full pressure head at the highest efficiency declined from 7.4 to 6.75 m; in other words, a change in the curvature of the blades in a fish pump impairs its performance. /111

It has been established that the best volute shape, from the viewpoint of the least energy losses on overcoming resistances, on condition that the stream is unimpeded, is a spiral. In some recent investigations, the following data have been cited from a test of two identical centrifugal pumps with an operating wheel diameter of 330 mm and volutes of different shapes.

Performance area	Annular shape	Spiral shape
Delivery in litres per second......	92,5	95,0
Pressure head, in metres...........	20.5	22,8
Horsepower.........................	30,8	30,7
Efficiency in percent..............	63,8	67,7

In addition, in a test of two centrifugal pumps with a spiral casing, a branch intake pipe 100 mm in diameter and a branch delivery pipe 125 mm in diameter, when an insertion piece that changed the shape of the volute from spiral to annular was fitted into one of the pumps, the following data were obtained.

Performance area	Annular shape	Spiral shape
Delivery in litres per second......	36,2	41,5
Pressure head in metres............	25,3	29,2
Horsepower.........................	23,2	26,7
Efficiency in percent..............	58,0	62,0

These data fully confirm the advisability of using a spiral volute in fish pumps.

When we tested the transparent fish pump with and without an insertion piece, we obtained the following data.

Performance area	With an insertion piece	Without an insertion piece
Delivery in litres per second......	23,0	25,0
Pressure head in metres............	6,0	6,75
Horsepower.........................	4,4	4,20
Efficiency in percent..............	45,0	54,0

The insertion piece sharply altered the spiral shape of the volute, and the performance of the fish pump dropped in all areas, which can be explained by the constriction of the free stream coming off the operating wheel as a result of the covering by the insertion piece of about 20% of the outer perimeter of the operating wheel (see Fig. 36).

The shape of the outlet, i.e., of the part of the volute that changes into the branch delivery pipe, also exerts great influence on pump performance.

For pumps that are transferring low-viscosity liquids (for example, /112 water and a mixture of water and fish), hydraulic losses depend mainly upon the transformation of velocity energy into pressure energy. In centrifugal pumps these transformations take place mainly in the outlet.

It has been established from numerous tests that when the area of the cross section of the outlet is increased, the performance of pumps in all areas improves (discharge, by 20 to 30%; pressure head, by 6 to 8%, and efficiency, by 10 to 11%). It has also been established that the shape neither of the outlet nor of the branch delivery pipe (oval or round) has any effect on these changes in performance.

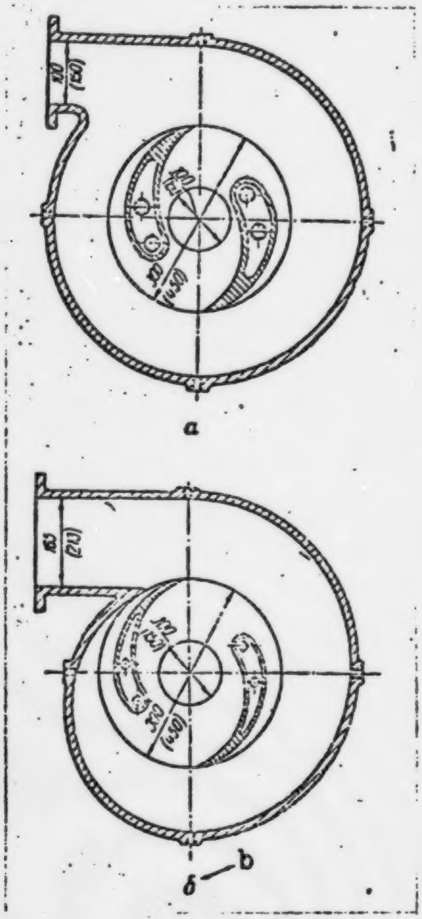


Figure 37' - The shape of a volute and of an operating wheel:

a - existing design of RB-100 and RB-150 fish pumps (dimensions, in mm, of the RB-150 are shown in parentheses); b - improved design of RB-100 and RB-150 fish pumps (dimensions of RB-150, in mm, are shown in parentheses).

Thus the design of fish pumps of the RB type should be improved mainly by changing the shape of the volute, increasing the cross section of the outlet and reducing to some extent the thickness of the ingoing ends of the blades. Moreover, stray currents of liquid will be reduced by decreasing clearances between the fish pump housing and the outer surfaces of the operating wheel. In Fig. 37a are depicted the shapes of the volute and of the operating wheel of the RB-100 and RB-150 fish pumps of the existing design, and in Fig. 37b, the corresponding elements of the recommended improved design.

The research that has been carried out permits a number of conclusions and proposals with regard not only to refining the design of the RB-100 and RB-150 fish pumps, but also to improving the operation of fish-pumping units of other model sizes that are active in industry. Existing fish-pumping units are used with little effectiveness because of the fact that the concentration of fish in the mixture that is pumped is quite low. /113
The main area in which fish are injured in fish pumps of existing design is the projection or "tongue", to the careful machining of which exceptional attention should be directed in the course of assembly. The operation of existing units may be somewhat improved through eliminating the bifurcation of the stream by the installation of an insertion piece within the volute. This piece, however, should be inserted in such a way that it will not constrict the free movement of the stream off the operating wheel.

The entry of air into the volute is not permitted during the operation of centrifugal fish pumps; therefore all such pumps should be supplied with air escape cocks in the upper part of the volute, while delivery conduits should exclude the possibility of the formation of air pockets in the line.

An abrupt change in the concentration of the fish that is being transferred cannot be permitted during the operation of fish pumps.

7. Centrifugal Fish Pump Drives

Centrifugal pumps are operated by electric motors and internal combustion engines. Nonsynchronous electric motors are most widely used in RBU-100 units, and ZIS-120 engines, in RBU-200 and RBU-250 units.

Various transmissions are used for transferring motion from the engines to the fish pump shaft with the required rotation speed, but the most frequently employed are cylindrical reduction gears, used in RBU-100 fish-pumping units, and gear boxes with clutches, supplied with the ZIS-120 engine.

The installation of electric motors and internal combustion engines and their drives is well known from special literature. Therefore only the briefest description of these elements of fish-pumping units is given here.

The Electric Drive of Small Fish-Pumping Units

A nonsynchronous short-circuited electric motor is the source of movement in the RBU-100 fish-pumping unit. The motor is connected by a clutch to a cylindrical reduction gear (see Fig. 28), which transmits the rotation of the fish pump shaft through a second clutch.

The nonsynchronous short-circuited motor consists of a stator assembled from steel sheets with grooves on their inner surfaces*, in which is inserted a three-phase winding of insulated copper wire, placed within the stator, and a rotor, located within the stator and secured to the shaft of the motor. The rotor has a winding of copper rods whose ends are short-circuited and soldered to special copper rings. The ends of the shaft rest on bearings located in the end covers of the electric motor housing. A ventilator fan for producing a current of air around the motor is mounted on the shaft; there are special openings in the housing for supplying air to the fan.

The winding of the stator is connected by a star or triangle connection and hooked up to a system with a voltage of 320/220 volts. The current in the windings of the stator creates a field which, interacting with the field of the rotor, causes the latter to rotate. The direction of rotation of the motor shaft is altered by changing over the ends of the wires supplying the current from the system to the motor.

---

* Translator's note. The term "surface" is here used as an equivalent of the Russian obrazuyushchaya, an adjective meaning "forming" and employed here as a substantive.

The motor is switched on with a knife switch mounted on a slate tile. /114

In order to protect the circuit, fuses designed for a current of no higher than 60 amperes are connected near the knife switch. The power of the motor in an RBU-100 unit is 4.5 kw and the rpm is 1,450.

The reduction gear consists of a single-stage gear and pinion with spiral gears located in an oil bath within a cast housing. The shafts of the gears rest in bearings located within the housing. The housing of the reduction gear is enclosed from above with a cover. The reduction gears are now manufactured in two models (II and III), but up to 1952 they were manufactured in three models, an interchangeable set of shafts and gears being supplied for the reduction gear of each model.

Description of Reduction Gear

	Model		
	I	II	III
Number of teeth	44/13	38/39	36/21
Gear ratio	3.39	2.00	1.71
Rpm of driven shaft	432	730	852

Thus where there is a reduction gear, the fish pump shaft can have three rotation speeds if the shafts and gears are interchanged. The reduction gear is connected to the motor and the pump by standard clutch couplings of the MUVP[*] type.

In order to change the shafts and gears, it is necessary to: disconnect the semicouplings[**] on the drive shaft and driven shaft; remove the cover of the reduction gear; take out the set of shafts, gears, bearings and semicouplings and insert another set that is equipped with bearings and semicouplings; change the oil; close the cover and connect the semicouplings.

The Drives of Large Fish Pumps

The ZIS-120 engine, which has been used in the RBU-200 and RBU-250 units for operating their fish pumps, has now been removed from production. Most large fish pumping units, however, have been equipped with this engine.

The ZIS-120 engine (see Fig. 28) is a four-stroke, six-cylinder carburetor engine operating on gasoline. It has a crank gear, a gas distributing mechanism and power supply[***], lubrication, cooling and ignition systems.

---

[*] Translator's note. MUVP is a Russian abbreviation for "finger sleeve coupling"..

[**] Translator's note. The term "semicoupling" is used here as an equivalent of the Russian "polumufta, for which no other equivalent (except perhaps "semiclutch") is available.

[***] Translator's note. The only suitable rendition available of the Russian pitanie, which means literally "feeding".

The crank gear of the engine serves to transform the forward motion of the piston into the rotary motion of the crankshaft. The cylinder block is of cast iron with cavities in which cooling water circulates. The cylinder block is enclosed from above by a head, in which are spherical compression chambers and cavities for cooling water that are connected with similar cavities in the cylinder block itself. A crankcase with a pan that is a reservoir for lubricating oil is adjacent to the cylinder block below. A crankshaft with crank handles is installed in the crankcase. A valve box enclosed by two covers is mounted on the side of the cylinder block.

The crankshaft has seven journals, located in bearings, and six connecting rod journals, on which the lower ends of the connecting rods are set. At one end of the crankshaft is a gear through which the gas distributing mechanism is operated. Here also is a ratchet for the starting crank, an oil seal and a pulley for driving the cooling pump. A flywheel is mounted on the other end of the shaft. To it is connected a clutch coupling. On the flywheel is a ring gear, with which the engine is started from the starter.

The gas distributing mechanism consists of a camshaft from which /115 are operated twelve valves that admit the fuel mixture to the cylinders and release combustion products from them. On this same shaft is mounted a cam, which operates a diaphragm pump that feeds gasoline from the fuel tank into the carburetor.

The fuel system consists of a diaphragm gasoline pump, a fuel sump, an air cleaner, a muffler, and a carburetor, where the fuel is atomized, evaporates, and mixes with air in a certain regulated proportion, and a fuel mixture forms, which is fed through the gas distributing system into the cylinders.

The lubrication system for lubricating rubbing parts provides for the lubrication of cylinders, crankpins, crank and connecting rod bearings, the cams of the distributing mechanism, etc. The oil system consists of an oil gear pump, coarse and fine filters, a reducing valve and distributing channels. A pan serves as a reservoir and sump for used oil. It is from this pan that oil is drawn in by a pump and fed through the filter system and the reducing valve to the lubrication points. At the same time, some areas (the bearings) are lubricated under pressure through lubrication channels, while others (the cams of the distributing shaft) are lubricated by having oil splashed on them.

The engine is cooled by a water pump and a TsN-6 pump mounted on the cylinder block and operated from a pulley at the end of the crankshaft. Both pumps are centrifugal, with multiple-blade wheels. The cooling system is supplied with water from a special tank by a water pump or with water from over the side [of a ship (or from over the edge of a wharf)] by a TsN-6 pump.

The electrical system of the engine, which is of 12 volts, secures the starting of the engine and the ignition of the mixture in the cylinders.

It consists of a storage battery and a DC generator, a relay regulator, ignition devices, a starter and DC electric starting motor, an ammeter, a control lamp and a wiring system.

The starter, which is equipped with an automatic electric device for connection to the flywheel through the coupling and gear of the engine crankshaft, serves to start the engine itself. During starting, the starter is supplied with current from the storage battery, which, in addition, supplies the ignition devices when the engine is turning over slowly.

A generator, which is switched on simultaneously with the starter, and is operated directly from the engine, is used for supplying power to the ignition devices when the engine is running at high speeds. Moreover, the generator develops current for recharging the storage battery. The operation of the generator is controlled by the relay regulator, which also ensures that it is automatically connected to and disconnected from the electrical circuit.

The ignition devices include spark plugs, an ignition coil, which transforms low-voltage current into high-voltage ourrent that is adequate for producing a spark, and a breaker-distributor, which, in accordance with the sequence of operation of the gas distributing system, sends current impulses into the cylinders for producing sparks.

The clutch coupling is mounted on the end of the flywheel and includes a friction device consisting of two driven metal discs covered with ferrodo* friction material, and two driving metal discs. The clutch coupling is operated from a crank; when the latter is pressed, the driving and driven discs come into contact, and movement is transmitted from the crankshaft of the engine to the primary transmission shaft.

The transmission consists of a multistage gear box located in a closed oil bath. Within are located the primary (drive) and driven (intermediate) shafts and the axle. The ends of the primary and driven shafts have been extended out. Sliding contacts with engagement forks connected to the shift lever have been set freely on the axle. On the /116 shafts there is a set of stationery and mobile gears that are engaged by the gear shift lever, which has been extended out. Together with forward and reverse movement, the following gear ratios are obtained: 0.81; 1.00; 1.90; 3.32; 6.00; 6.24; and 6.70.

The end of the driven shaft that extends out has been supplied with a semicoupling that is set on grooves.

8. The Operation of Centrifugal Fish Pumps

The correct operation of a centrifugal fish pump ensures its trouble-free operation, and reduction to the minimum of mechanical damage to the fish that is being pumped.

---

* Translator's note. The term "ferrodo", which is spelled the same in Russian and in English, is listed as an automotive term in Russian-English Polytechnical Dictionary by L.N. Kondratov, published by the State Publishing House for Technical and Theoretical Literature, Moscow, USSR, 1948.

The trouble-free operation of a centrifugal fish pump depends mainly upon the absence of air in its intake line and internal cavity. For this purpose, all connections on the housing and particularly on the intake hose of the fish pump must be hermetically tight. A systematic check must also be made of the tightness of the packing in the stuffing box, and it must be made certain that water is continually fed to its hydraulic seal. Under normal conditions, the stuffing box has a tight packing, but it does not retard the rotation of the shaft. During operation, water flows out of the stuffing box in drops or a thin stream, which indicates the effectiveness of the hydraulic seal.

The intake hose of a centrifugal fish pump, during priming before operation, and during operation, should rise only laterally to the fish pump; under no circumstances should it have bulges where air pockets could form. It is very difficult, and occasionally impossible, to start a pump when pockets form in the intake hose. The working mixture contains a certain quantity of air, which can be separated from the water. Where there are bulges in the hose, the air that is separated from the water accumulates in them, as a result of which a break can occur in the stream during the operation of the fish pump.

Since air can always appear within a centrifugal fish pump, it must be released through an upper opening in the pump housing. During prolonged operation, a systematic check should be made for the presence of air in the fish pump; this air should be removed by turning on, for a short time, a small cock in the upper opening.

Care must be taken that the end of the intake hose, which is equipped with a return valve, does not become exposed during operation and does not come too close to the surface of the working mixture that is being pumped. Otherwise air may rush into the hose.

The entry of air into the pump presents no hazard when the pump is being primed with the aid of a vacuum, and the priming process itself is in this case automated.

The end of the intake hose must not be permitted to approach the bottom too closely, since it can adhere to it. Not is it recommended to bring the end of the intake hose too close to the bottom when herring /117
are being pumped from drag seines, since in this case the pump will draw in soil (sand and mud), which gets clogged in the gills of the fish and damages it.

Of great importance for the correct operation of a centrifugal fish pump are the good condition of the return valve and its capacity to hold water, if it is located at the end of the intake hose, or air, if it is situated on the pressure side. Especially to be avoided is the entry of fish under the gate of the valve, owing to which it will be impossible to prime the fish pump with water. In all cases, therefore, there must be free access to the return valve in order to inspect and rapidly clean it.

Before work begins, the intake line must be checked for tightness, after which a check should be made to see if the entire system is being properly primed with water. The system may be considered fully primed if water begins to flow out of the small upper air cock. After the operation of the fish pump has been checked on water, the unloading of the mixture of fish and water may begin.

The reduction to the minimum of the amount of mechanical injury to fish depends upon many factors. The absence on the inner surfaces of the pump, and its utility systems, of blisters and burrs, and the absence of sharp baffles in the joints of the pipes and hoses is the first and essential condition for the safety of the fish. Before the operation of the fish pump begins, the forward cover of the volute must be removed and all inner surfaces of the fish pump thoroughly checked and cleaned; it must also be made certain that the operating wheel is correctly balanced.

The selection of the correct number of turns of the operating wheel of a centrifugal fish pump and the determination of the limit of its applicability represent the second necessary condition for its good operation. The number of revolutions of a centrifugal fish pump should be checked when it is operating with a full load, and it should be made certain that this number corresponds to the rated number. For this purpose, on every fish-pumping unit there should be a device for measuring the number of revolutions of the fish-pump shaft - a tachometer, a tachoscope*, or simply a revolution counter and a clock.

The composition of the working mixture is of great importance for the correct operation of a fish pump. A fish pump cannot pump very thick working mixtures. If an attempt is made to pump such mixtures, the engine is overloaded, the number of revolutions of the fish pump wheel drops, and the fish that is being pumped in large quantities suffers mechanical injury from being crumpled (some fish burst). When the working mixture is diluted, the discharge of fish by the pump decreases. When these conditions are taken into account, it is considered that the best working mixture is one in which there is a ratio of 1:3 to 1:5.

The maintenance of the correct concentration of fish in the working mixture is one of the most important factors contributing to the good operation of a centrifugal fish pump. Here much depends upon the skill /118 of the operator pouring out the fish at the fish-pumping unit.

When fish are pumped from various seines, the concentration of the working mixture is regulated partly by "drying" the seine, i.e., by drawing the webbing towards the intake hose. Where there are large quantities, however, the fish in the seine become arranged in layers of different concentration, the surface layer having the least concentration, and the submerged layer, the greatest. Where there are large catches, the composition of the working mixture is regulated by lowering the end of the intake hose to various depths. Thus the worker pouring out the fish establishes the desired concentration. The composition of the working mixture is usually controlled visually at the water separator.

---

* _Translator's Note._ A direct rendition of the Russian _takhoskop_.

When fish is pumped from ship's holds, the working mixture is formed artificially, by pouring water into the hold. In this case the hold should have a solid, watertight sheathing. The holds are flooded by centrifugal pumps with a discharge equal to or somewhat greater than that of the fish pump. Usually, fish pumps are also used as flooding pumps. Thus a fish-pumping unit should consist of two identical fish pumps. In some cases the used water, after it has passed through the water separator, is directed back into the hold along a conduit or trough. Here the necessity for a second fish pump no longer arises; the regulation of the composition of the working mixture, however, is hampered.

Where catches have been good, the holds of fishing and transport ships are usually overflowing with fish. The free space necessary for the formation of a working mixture, is lacking. In this case, the following action is taken. A small depression is dug in the mass of the fish with a zyuz'ga*; into this depression are inserted the intake hose of the fish pump and the delivery hose of the flooding pump. The compact mass of fish does not readily admit water, and therefore around the end of the intake hose of the fish pump there very rapidly forms a covering layer of water. The fish pump is immediately switched on, and when it draws in fish, it creates a free space for the formation of a working mixture.

---

* Translator's note. No equivalent is available for this word, which is believed to be a local term denoting possibly a small scoop.

As the fish are pumped out, there is more and more water in the hold. The fish, however, are irregularly arranged in the hold, lying in a dense mass on the bottom and in a thinner layer on the surface. The composition of the working mixture, when fish are being pumped out of either seines or holds, is regulated by immersing the hose in various areas of the mass of fish.

A boom, or better still, a crane, must be used for operations with intake hoses at a fish-pumping unit on a wharf.

At the end of work in which lengthy interruptions occur, the entire system must be flushed with pure water.

When a centrifugal fish pump is installed, care must be taken /119
that the intake height does not exceed that which is permissible. If this condition is not observed, cavitation can occur which, in addition to damaging the parts of the pump, can involve injury to the fish.

The optimum intake height for centrifugal fish pumps is about 4.5 m from the surface of the pumped liquid to the axle of the operating wheel of the fish pump. In many cases, fish-pumping units operate under conditions in which there are considerable fluctuations in the levels of bodies of water owing to tides, wind, and seasons. Where the fluctuations in the water level exceed 3 to 3.5 metres, a fish-pumping unit should be made mobile rather than stationary and mounted on a pontoon, which will automatically follow all fluctuations of the level in a given body of water.

For the most effective use of fish-pumping units, which are highly efficient machines, steps must be taken to reduce the time spent on all auxiliary operations (the approach and departure of ships, adjustments, etc).

Chapter V

/120

MULTISTAGE FISH-PUMPING UNITS

1. The Concept of the Multistage Pumping of Fish through Pipes

Most fish-pumping units transfer a mixture of fish and water into a conduit, through which the mixture proceeds directly to the processing area or into an intermediate transport facility, for example, a hydraulic pan conveyer.

A fish pump lifts a mixture of fish and water to a certain height, which includes the intake height (from the water level in the area that is being cleared to the centre of the fish pump), the delivery height (from the centre of the fish pump to the edge of the intake pipe) (including the height of the fish-receiving devices above ground), and the difference in the geodetic elevations of the centre of the fish pump and the point in the locality at which the fish-receiving facility is situated.

The conduit offers resistance to the mixture of fish and water that is pumped through it. The longer the conduit and the more bends, elbows, connections and flanges it includes, the greater this resistance. Upon emerging from the conduit, the stream of the mixture moves at a certain speed, and consequently, possesses a certain reserve of kinetic energy.

The pressure head developed by a fish pump is expended on raising the mixture of liquid and fish to the required elevation, on overcoming the resistances of the conduit, and on creating the stream's reserve of kinetic energy at the exit from the pipe (see Fig. 38).

What we have just stated may be expressed by the following equation:

$$H_n = H_{vs} + H_g + H_k + \Sigma h_w + \frac{v_k^2}{2g}, \qquad [60]$$

where H_n is the full pressure head, in metres, developed by the fish pump at n number of revolutions of the operating wheel;

H_{vs} is the intake height in metres;

H_g is the geodetic height of delivery, in metres;

H_k is the structural height of the fish-receiving facility, in metres;

$\sum h_w$ is the sum of the pressure head losses on resistance in the intake and delivery conduits, in metres;

v_k is the speed in the cross section at the edge of the pipe, in m/sec;

$\frac{v_k^2}{2g}$ is the kinetic energy of the stream as it pours out;

$g = 9.81$ m/sec^2 is the acceleration of the force of gravity.

The total height to which a mixture is raised by a fish pump is /121
fairly limited and amounts to 2.5 to 3.2 m for water-jet fish pumps and 8 to 11 m for centrifugal pumps. In a number of cases, the pressure head developed by a fish pump is insufficient to cover all of the components

of the right side of equation [60]. In order to obtain a pressure head sufficient to cover all of these components, two courses of action are possible:

1) the total pressure head developed by the fish pump may be raised by increasing the number of revolutions of the operating wheel in a centrifugal fish pump or by opening the starting valve and imparting a greater speed to the stream of operating water at the entrance to the mixing chamber in a water-jet fish pump;

2) the sum of the terms in the right side of equation [60] may be reduced.

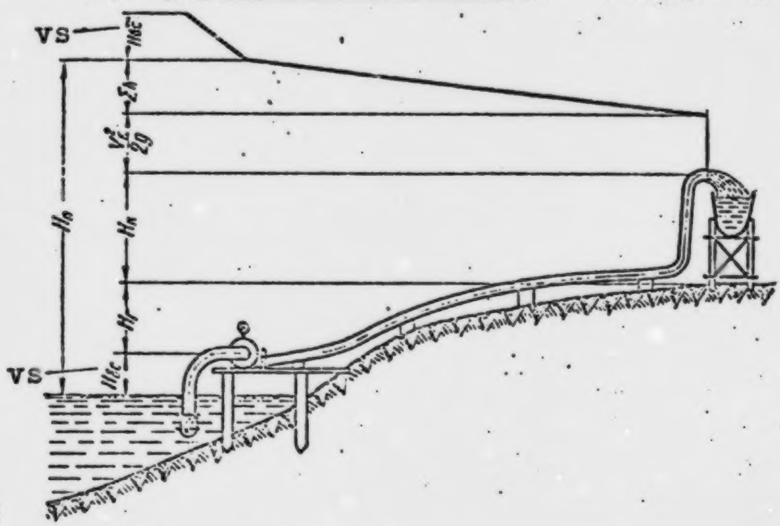


Figure 38 - Diagram of the distribution of the pressure head of a fish pump.

The increasing of the pressure head in a fish pump, however, is limited by conditions pertaining to the safety of the fish. If we now proceed to reduce the sum of the terms in the right side of equation [60], we can observe at once that for each specific instance the values H_{vs}, H_{g}, and H_{k} are fixed and cannot be arbitrarily altered. The value of the kinetic energy reserve of the stream as it pours out is usually taken within minimum limits and cannot be assumed to be less than 0.11 to 0.16 metres, which corresponds to a discharge speed of 1.5 to 1.8 m/sec on the average throughout the cross section, i.e., to the normal conveying speed within the pipe.

Thus only the sum of the losses of pressure head within the conduit may be reduced.

Losses of pressure head in a pipe depend upon its length and diameter. The length of a fish conduit pipe is in each specific instance fixed and cannot be reduced. Thus only the diameter of the pipe may be increased, but again only to the extent where the speed in the pipe will not fall below the conveying speed. We can in this way reduce losses in pressure head only negligibly, since the reduction of pressure head losses is limited by the value of the conveying speed. /122

In cases where the pressure head of a fish pump is insufficient to cover all deliveries and losses, two-stage pumping is employed, in which the fish is passed through two pumps connected in sequence. Here the total pressure head in the fish conduits increases to the value of the sum of the pressure heads of the two fish pumps, which permits the fish to negotiate even long conduits and high lifts.

When designing fish-pumping units that convey fish for a considerable length and height, the designer is confronted with a complicated problem - to find the minimum dimensions for the pipes of the fish conduit and the [required] number of revolutions of the pump, while providing for the conveyance of the necessary quantity of fish to the required area (see Fig. 39).

By way of example, we shall analyse the graphic solution of such a problem.

Suppose that it is required to convey fish with an RB-150 fish pump for a distance of 600 metres and to elevate it 15 metres. It is evident that this cannot be done with a single fish pump; therefore we shall use a two-stage unit consisting of two RB-150 fish pumps and shall attach the delivery hose of the first pump to the branch intake pipe of the second.

We shall adopt several variants of a possible solution to the problem. Let us assume the following variants of possible values: the number of revolutions of the fish pump $\underline{n} = 730$, 600 and 500 per minute; the diameters of the fish conduit pipes $\underline{d}_{*r} = 150$, 200, and 250 mm; the

---

* Translator's note. The first element of the subscript of $\underline{d}$ is indistinct in the original text.

elevations at which the second fish pump is installed H = + 8 and + 9 metres, in conformity with which the lengths of the intermediate pipe will amount to 450 and 500 metres.

We shall plot only in the axes of coordinates the characteristic curves Q - H and Q - N for the RB-150 fish pump at 730, 600 and 500 rpm, and the curves Q - H for pipes with diameters of 150, 200, and 250 mm.

The curves Q - H and Q - N for the fish pump in Fig. 39 have been plotted by conversion according to formulas for dynamic similarity, i.e., with whole indices of the degrees of ratios of the numbers of revolutions (this is not quite accurate if data from research on fish pumps is taken into consideration; see Chapter IV).

The curves Q - H for the three pipes that we have selected have been plotted from tables for pure water, which is acceptable. The first RB-150 fish pump must overcome resistance in the pipe and the geometric height of elevation to the second fish pump; hence using the variants adopted for the example, we establish the beginning of the coordinate system for these pipes at distances of + 8 and + 9 metres from zero and plot for them two bundles of curves.

On the x-axis we plot the deliveries in litres per second, and on the y-axis we establish four scales: on the left, the scale of the full pressure head (H), in metres, developed by the fish pump, and the horsepower (N) consumed by it; on the right is the loss in pressure head /123 in the pipe (h_8 and h_9) in metres where the fish pump is installed at different elevations.

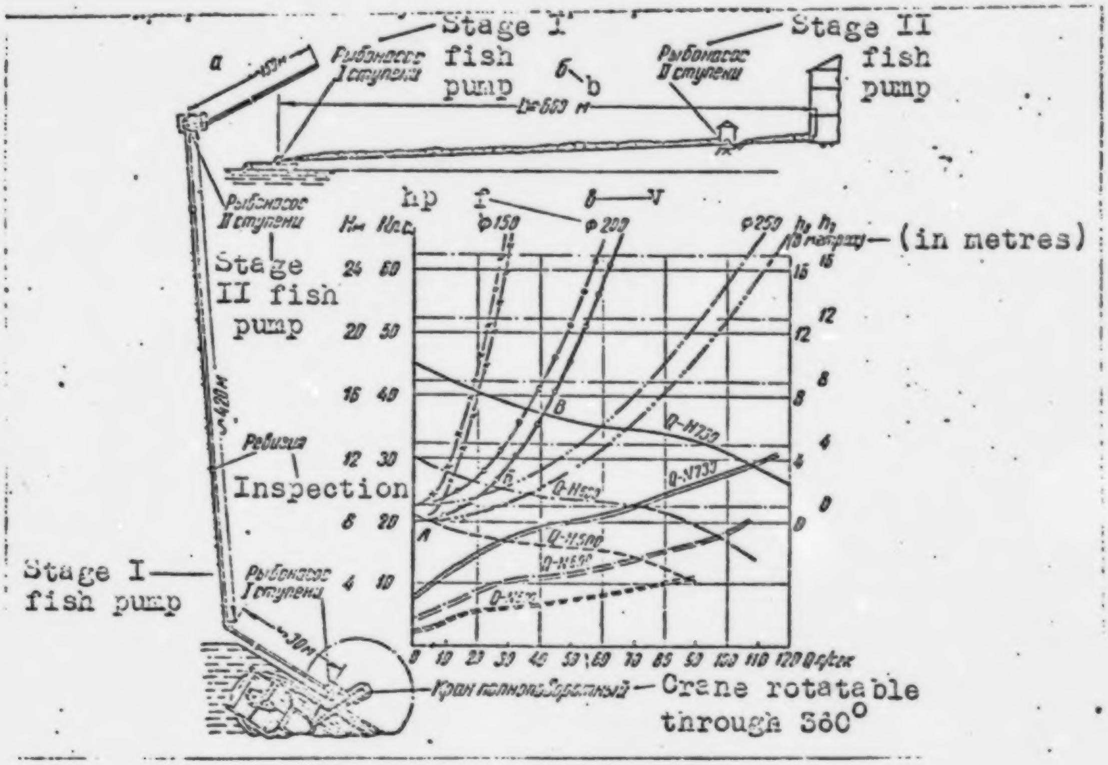


Figure 39 - Graphic calculation of the operating conditions of a two-stage fish-pumping unit:

a - plan of fish conduit and fish pumps; b - plane diagram of fish conduit; v - characteristic curves of RB-150 fish pump where n = 730, 600, and 500 rpm, and of fish conduits 150, 200, and 250 mm in diameter when working with pure water (the lengths of the first pipe are 450 and 500 metres, and the second fish pump is located at elevations of + 8 and + 9 metres).

When we examine the points of intersection of the plotted curves Q-H for the fish pump and Q-H for the pipes, we find that the optimum is point (B) of the intersection of the curve Q-H (for a fish pump where n = 600 rpm) with the curve Q-H for a pipe with a diameter of 200 mm where the second fish pump is installed at an elevation of + 8 m, since point A correlates to a discharge that is too low, and point V, to too large a number of revolutions of the fish pump wheel; this value should be less in order to ensure conditions for the safety of the fish.

It may be seen from the example that in a two-stage operation /124 the second fish pump picks up the stream of water and fish at the moment when the pressure head of the stream is almost completely spent on overcoming the geometric height and the resistances of the pipe, and sends it further.

The method of pumping fish using several pumps connected in sequence was developed in the Soviet Union by a number of innovators (N.N. Chirkov, D.D. Shed'ko and others) from 1946 to 1948.

Even the first investigators of this method directed attention to the fact that in two-stage pumping both fish pumps can work without strict synchronization of the numbers of revolutions of their operating wheels. It was also noted that the quantity of damaged fish in pumping operations with two fish pumps showed virtually no increase over that resulting from pumping with one pump. It is evident that a large quantity of fish which were not sufficiently firm for a given set of operating conditions of a fish pump, were damaged in the first pump and that all the remaining fish, whose firmness corresponded to the operating conditions, passed through both fish pumps without injury.

All of the reasoning related to the passage of fish from the first fish pump to the second, can also be extended to a third and subsequent fish pumps. Thus we arrive at the concept of the multistage pumping of fish, which enables us to increase immensely the range of conveyance of fish through fish conduits and to increase the total height to which fish is raised in hydraulic engineering systems.

2. Centrifugal-Action Multistage Fish Pumps Units on Sakhalin

In 1948 N.N. Chirkov tested a two-stage unit on pumping Sakhalin spring spawning herring. The unit consisted of two RB-150 centrifugal fish pumps connected in sequence: one was installed afloat (on a kungas), and the second was installed as a stationary facility (on a wharf). The distance between the fish pumps in Chirkóv's experiments was 300 metres.

Subsequently, at enterprises on Sakhalin that processed spring spawning herring, a system of two-stage operation of the RB-150 and RB-200 fish pumps was adopted whereby both fish pumps were installed on kungasy and they operated while afloat. The first fish pump, which pumped herring from a net bag, was stationed at a roadstead, and the second, which transferred the herring into the hydraulic pan conveyers of the fish plant, was stationed at the shore (see Fig. 40).

Both fish pumps operated at 450 to 500 rpm, developed a pressure head of 8 to 10 metres, and had a daily load of 120 to 150 tons of herring.

The intermediate fish conduit was laid on floats and was itself /125
a flexible hose (canvas or rubber).

It must be noted that fish conduits made of hose and mounted on floats do not work completely satisfactorily at sea. They cannot withstand even moderate agitation of the water and frequently go out of order. Under these conditions, canvas hoses frequently break, as a result of which the amount of damage to the fish increases.

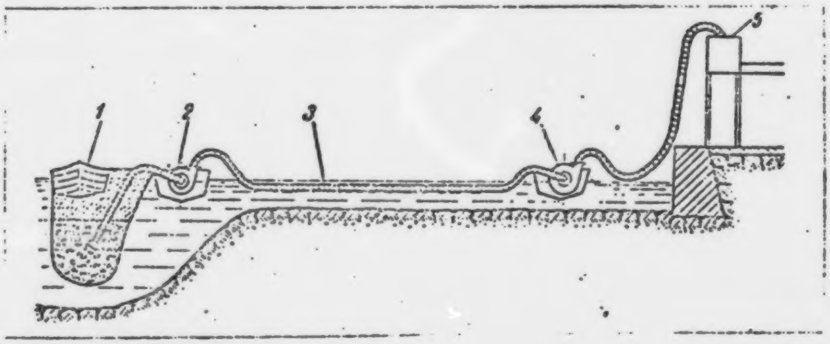


Figure 40 - Diagram of installation of two RB fish pumps on kungasy:

1 - kungas with a net bag filled with herring; 2 - RB-150 fish pump of first stage; 3 - intermediate fish conduit - a canvas hose; 4 - RB-200 fish pump of second stage; 5 - receiving section of fish plant hydraulic conveyer.

Units on the Sea of Okhotsk (double)

In 1948 at enterprises of the Okhotsk Fish Trust D.D. Shed'ko, M.I. Antipov and others set up the first two-stage unit, consisting of a centrifugal fish pump installed on a kungas and a fish pump of the same type installed on shore. In the first such unit the distance to which the fish was conveyed totalled 88 metres; the height to which the fish was raised, however, rose to 12 and 13 metres as against 6.5 metres during operations with a single fish pump (see Fig. 41). Subsequently, the conveying distance was considerably increased. Prior to the installation of a two-stage fish-pumping unit for unloading herring, every year wharves were built which were dismantled for the winter; while [fish unloading] operations were carried out, the wharves were subject to the destructive action of storms, ice and surf. /126

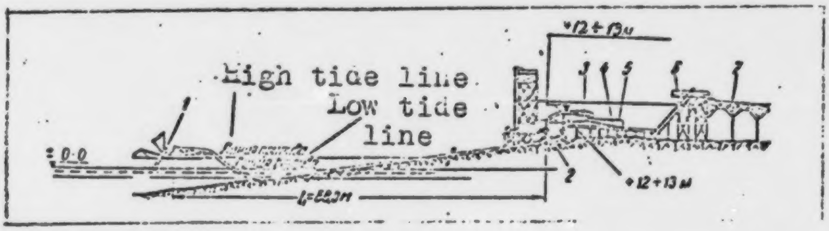


Figure 41 - Diagram of a two-stage fish-pumping unit with a floating fish pump in the first stage and a stationary fish pump in the second stage:

1 - RB-150 fish pump of first stage (on kungas); 2 - RB-150 fish pump of second stage (on shore); 3 - diffuser; 4 - water separator; 5 - permanent receiving platform; 6 - measuring bins; 7 - trough of hydraulic conveyer.

The two-stage fish-pumping unit permitted a solution to the problem of unloading herring onto the shore under the conditions of a surf zone, moving ice and stormy weather.

The attempt to increase the conveying range, which was brought about by the conditions of the locality, continually compelled an increase in the distance between the fish pumps, which presented a number of outstanding drawbacks. This led to another solution in which the fish pumps were brought closer together, and the total conveying distance and height increased.

As D.D. Shed'ko indicates, the following circumstances prompted this solution. In order to pump fish out of kungasy at a roadstead it was necessary to have two fish pumps with equal discharge, of which one would pump a mixture of fish and water from a kungas, and the other would pour water into the kungas for the formation of this mixture.

Where fish were pumped from net bags, the need for a second (flooding) fish pump no longer arose. It seemed possible to connect these two fish pumps in sequence and to obtain in this way a two-stage fish-pumping unit which would be capable of conveying fish from a net bag at a roadstead for a considerable distance to the shore.

In 1950 M.I. Antipov and A.K. Lyakhov proposed to fit out a two-stage fish-pumping unit on a twenty-ton kungas (see Fig. 42). In this unit two RB-200 fish pumps are operated by one ZIS-120 engine with a V-belt drive suggested by V.B. Kokhanovich.

Here much better use is made of the ZIS-120 engine than in single-stage RBU-200 units. [In this arrangement] the engine imparts rotation to a transmission mounted on blocks in the diametric plane of the kungas. Rotation is imparted from the transmission with a V-belt drive to two RB-200 fish pumps operating with an equal number of revolutions.

An intake hose with a standard return valve on its end is connected to the fish pump of the first stage. The hose is maneuvered using a ship's boom with a hand winch.

The delivery hose of the fish pump of the first stage is connected to the branch intake pipe of the fish pump of the second stage, and the delivery hose of the fish pump of the second stage is connected to the fish conduit discharging the mixture of water and fish onto the shore. Hoses 250 mm in diameter are used for the fish conduit.

A two-stage unit of this type has permitted the conveying range to be increased to 400 m with a total lift of up to 14 m.

The unit is highly efficient in pumping herring from net bags /128 at a roadstead. A net bag containing from 400 to 600 centners [40,000 to 60,000 kg] of live herring, is suspended from a kungas or from a frame on a floating pontoon and is set up in the roadstead, where there stands at anchor a two-stage fish-pumping unit (see Fig. 43a), which pumps a mixture of water and fish from the net bag and conveys it through a system of pipes and hoses to receiving and measuring bins and water separators installed on shore.

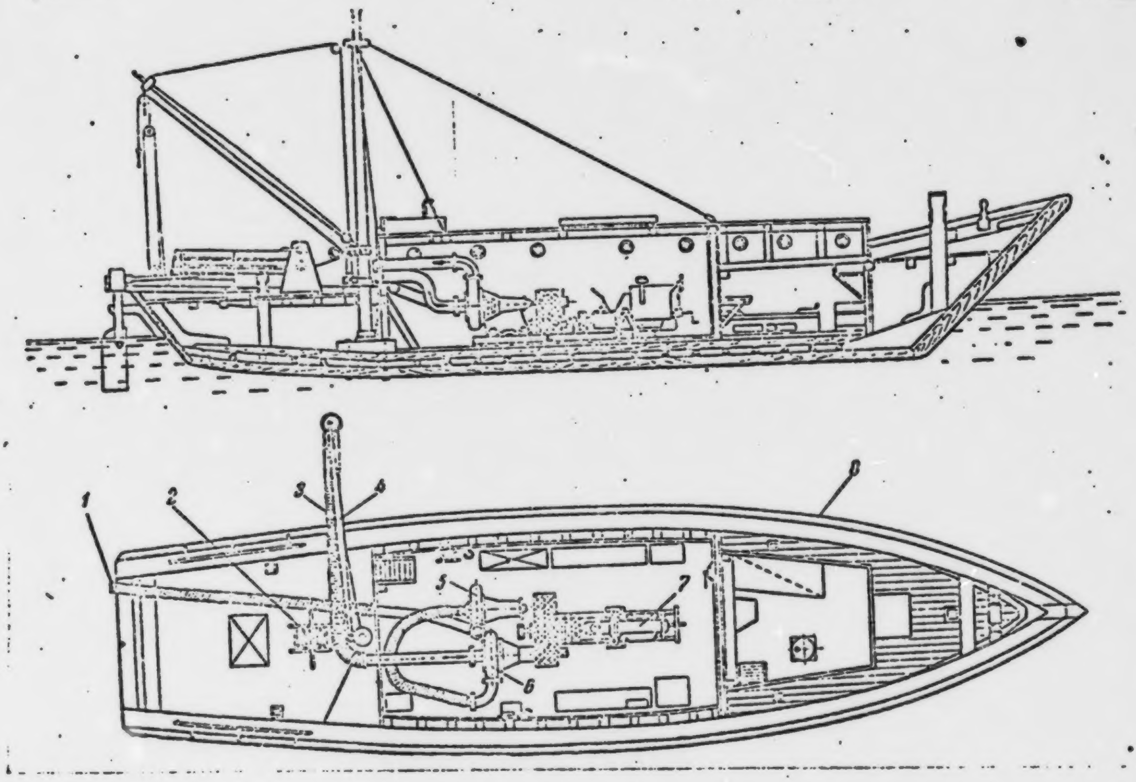


Figure 42 - A two-stage fish-pumping unit on a kungas:

1 - fish delivery conduit; 2 - winch; 3 - intake hose; 4 - boom for raising hose; 5 - fish pump of second stage; 6 - fish pump of first stage; 7 - ZIS-120 engine; 8 - kungas with cargo capacity of 20 to 25 tons.

Under such operating conditions, fish is unloaded without interruption during windy weather and irrespective of the presence of a surf zone or ice at the shore. The shallow water of the Okhotsk coastal areas has no effect on the delivery of fish to the shore, and the drying of the shore owing to tidal fluctuations, which ordinarily hampers the delivery of kungasy or net bags to the shore, represents no obstacle.

A further development of the method of multistage pumping of fish was the creation of the three-stage fish-pumping unit, produced at the Inya Fish Plant of the Okhotsk State Fisheries Trust (see Fig. 43, b).

The fish-processing centres of this plant are located on the bank of the Inya River, which flows into the Sea of Okhotsk and is separated from it by a long, narrow spit. The trap nets for catching herring were arranged in such a way that the fishermen, when they were conveying fish to the shore had to go around the spit, enter the river and move upstream, completing a journey of about 20 kilometres from net to fish plant. This consumed a great deal of time (about five hours), which was particularly valuable during the fishing season. During the prolonged conveying, the quality of the fish deteriorated.

In 1955, in order to accelerate the delivery of fish to the plant, a three-stage fish-pumping unit was used which consisted of an RB-200 two-stage centrifugal fish-pumping unit installed on a kungas, and a single-stage RB-200 fish-pumping unit connected to it in sequence. The two-stage fish-pumping unit was located at sea beyond the spit, and the single-stage unit, on the river. The distance between the fish-pumping units was about 350 metres, the total length of the hydraulic conveying system, about 500 metres, and the total height to which the fish were lifted, about 10 metres.

Both fish-pumping units were connected with a canvas hose. Since the strength of canvas hoses is fairly limited, when the three-stage fish-pumping unit was being planned, it was feared that when the three stages were connected on one kungas the pressure head developed by them could prove to be too much, and the hose could burst. In this unit, therefore, the third stage was removed to a considerable distance from the first and second stages and, in this way, the hose operated with the greatest pressure head developed by only two stages, i.e., about 18 metres.

The results of the operation of the three-stage fish-pumping unit were good. Observations of the operation of the unit have shown that /130 in three-stage pumping there is virtually no increase in the quantity of damaged fish as compared with pumping by single-stage and two-stage fish pumps. At the same time, since the duration of conveyance of the fish from the seine to the factory has been reduced, instances where raw fish of reduced quality have been turned in have completely ceased: almost all fish turned in to the fish plant has begun to arrive live. As a result of the freeing of a launch and kungasy which were occupied in the conveying of herring, there has been a saving of more than 82,000 roubles, and labour input has dropped significantly, owing to which the net cost of fish production has decreased by 1.4%. Two men, who had ordinarily accompanied the fish to the fish plant, have been released from the fishing crew.

Thus the application of three-stage fish pumping has yielded a considerable economic benefit, facilitated the labour of fishermen and workers and contributed to an improvement in the quality of fish production.

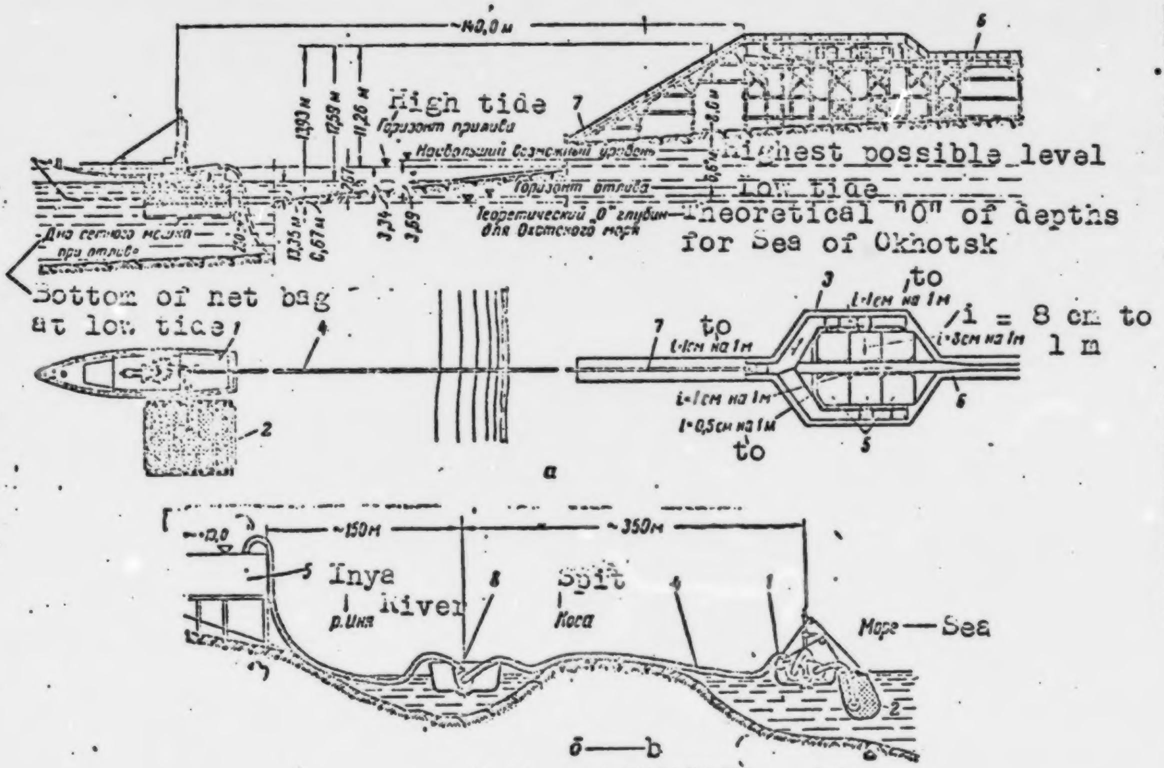

~140,0 м
6
13,93 м
12,59 м
11,26 м
High tide
Горизонт прилива
7
Наибольший возможный уровень
8,6 м
Highest possible level
Горизонт отлива
Low tide
Теоретический „0" глубин для Охотского моря
Theoretical "0" of depths for Sea of Okhotsk
Дно сетного мешка при отливе
2,0
12,35 м
0,67 м
2,67
3,34
3,59
6,5 м
Bottom of net bag at low tide
1
4
2
7
to
i=1см на 1м
3
to
i=1см на 1м
i = 8 cm to 1 m
i=8см на 1м
i=1см на 1м
i=0,5см на 1м
to
5
6
a
~12,0
~150м
~350м
5
Inye River
р.Иня
8
Spit
Коса
4
1
Море — Sea
2
б — b

Figure 43 - Diagram of the utilization of a floating fish-pumping unit for unloading herring from a net bag:
a - two-stage; b - three-stage;
1 - ship with RB-200 two-stage unit; 2 - net bag; 3 - receiving pier; 4 - canvas hose; 5 - receiving and measuring bins and water separators; 6 - hydraulic conveyer; 7 - fish conduit; 8 - ship with single-stage RB-200 unit (third stage).

---

3. Two-Stage Ejection and Composite-Action Fish-Pumping Units

In order to increase the range and conveying height of water-jet fish pumps, N.F. Chernigin proposed to combine NCh-3 water-jet fish pumps in pairs, creating two-stage units from them.

A Two-Stage Unit of NCh-3 Water-Jet Fish Pumps

This unit (see Fig. 44) is designed for unloading fish at a roadstead. The fish-pumping unit of the first stage is set up on a kungas standing at anchor in the roadstead and conveys a mixture of water and fish to the branch intake pipe of the second-stage fish pump, which is installed in a stationary position on a wharf.

The distance between the fish pumps, which is in this case approximately equal to the total distance for which the fish is conveyed, amounts to 80 to 100 m, with a total lift of 3 to 4 m.

Rubber hoses 200 to 250 mm in diameter and a metal pipe laid on the bottom are used for connecting the fish pumps of the first and second stages. Thus it has been found possible to make a considerable increase in the range and a slight increase in the lift of water-jet pumps as well by converting them to two-stage operation.

A Combined Fish-Pump Unit

Centrifugal fish pumps cannot unload fish from active fishing ships or kungasy without additional facilities for flooding holds with water, which is necessary in order to create a fish-and-water mixture of the required concentration in a ship's hold. This circumstance, as well as /132
a desire to improve the quality of the work of a centrifugal fish pump,

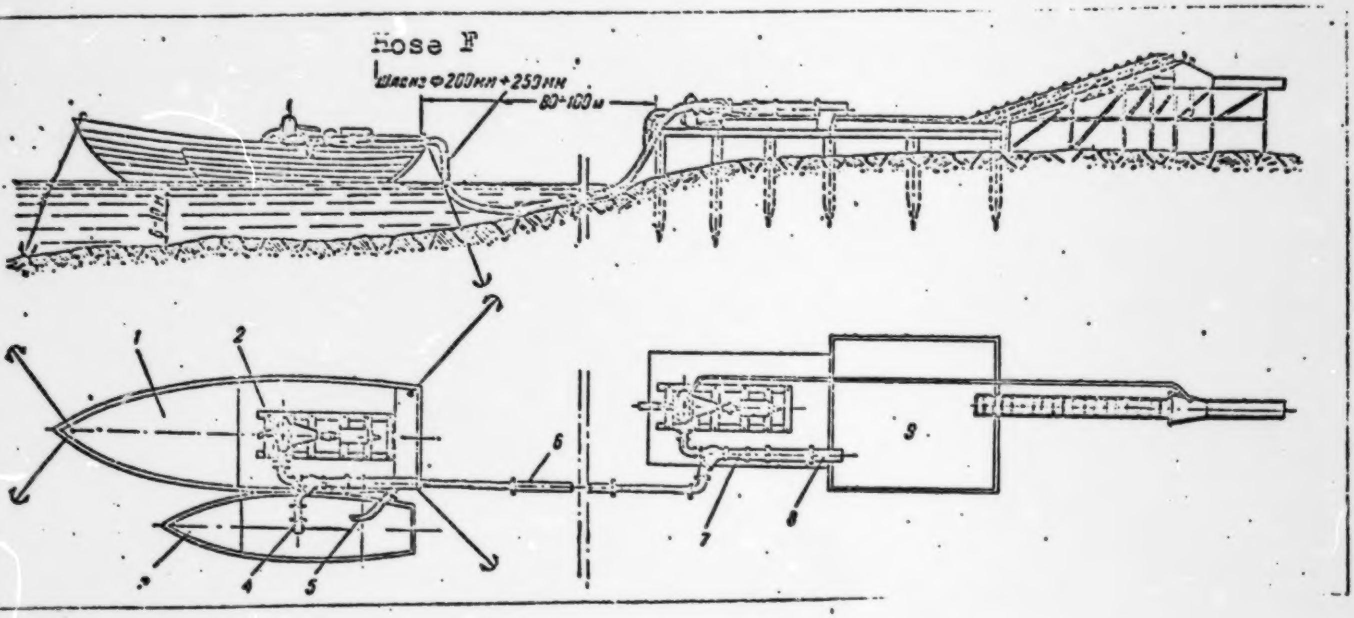


Figure 44 - A two-stage unit of NCh-3 water-jet fish pumps:

1 - cargo kungas; 2 - fish pump on kungas; 3 - kungas with fish;
4 - intake pipe; 5 - flooding hose; 6 - fish delivery conduit;
7 - fish pump on wharf; 8 - water separator; 9 - wharf.

---

led to the creation of a combined two-stage unit of the NCh-3 and RB-250 fish pumps. The scheme for a combined unit was developed by the Mechanization Laboratory of the Kamchatka Division of the Pacific Scientific Research Institute of Ocean Fisheries and Oceanography [TINRO].

In 1951 at one of the fishing places of the Krasnyi Truzhenik ["Red Worker"] Collective Establishment of the Bol'shretsk Region in Kamchatka a combined two-stage unit consisting of the NCh-3 and RB-250 fish pumps was created for receiving salmon immediately at the fishing place and conveying them live through pipes. The unit was set up by the Chief Directorate of the Fishing Industry in Kamchatka [Glavkamchatrybprom] and by the Mechanization Laboratory of the Kamchatka Division of TINRO. The following advantageous features of the NCh-3 fish pump were used in this unit: no disruption of operation when drawing in air; good work at an intake height of up to 3 metres, and reliability of operation with no return valve on the intake hose. These features were combined with an advantageous quality of the RB-250 fish pump - the capacity to create, in the mixture of fish and water, the high pressure head necessary for moving this mixture through pipes for a considerable distance.

On the other hand, the disadvantages of the NCh-3 fish pump (low lift) and of the RB-250 fish pump (interruption of work during the entry of air into the mixture, and low intake height) were mutually compensated in the joint operation of both pumps.

The shortcomings of the combined unit include its awkwardness and its heavy consumption of power. Fig. 45 contains a diagram showing the layout of the equipment of the unit that we have described for pumping live fish. A wooden trap with its open end facing the current was placed at the point where the drag seine was lowered so that the river current would assist the passage of fish from the trap to the bell mouth of the fish intake conduit. A net trap 10 metres long was connected to the wooden trap for convenience in driving the fish from the bag of the drag seine.

The effect (on the passage of fish to the fish pump) of imprecision in lowering the drag seine was eliminated with the help of the net trap. In addition, the net trap was used as a supplementary container for keeping fish alive in large catches.

The fish intake conduit of the first-stage NCh-3 fish pump was connected to the mixing chamber. The NCh-3 fish pump operated with the aid of a jet of water fed by a centrifugal pump operated by a ZIS-5 engine. The pump drew pure water in from the river through a pipe with a valve at its end.

The NCh-3 fish pump terminated in a closed water separator, with which air was removed from the mixture of fish and water before it entered the RB-250 fish pump of the second stage.

After passing through the water separator, the mixture of fish and water of the required concentration, and without an admixture of air, entered the intake opening of the RB-250 pump through a hose. The RB-250 fish pump operated extremely efficiently with such a mixture, creating a pressure of up to 14 metres of a column of water and, what was most important, it pumped sockeye, chum and pink salmon virtually without damaging them. /133

In order to ensure normal operation of the RB-250 fish pump, the content of fish in the mixture should be about 10%. This means that there must be 9 or 10 tons of water for each ton of pumped fish. Although dilution of the mixture with water is necessary in order that salmon may not be injured when passing through the RB-250 fish pump, there is no necessity for such a large quantity of water after [the fish have passed through] the pump. For the successful passage of a mixture of water and fish through the pipes it is sufficient that the content of water in the mixture represent up to 60 and 70% of the total volume.

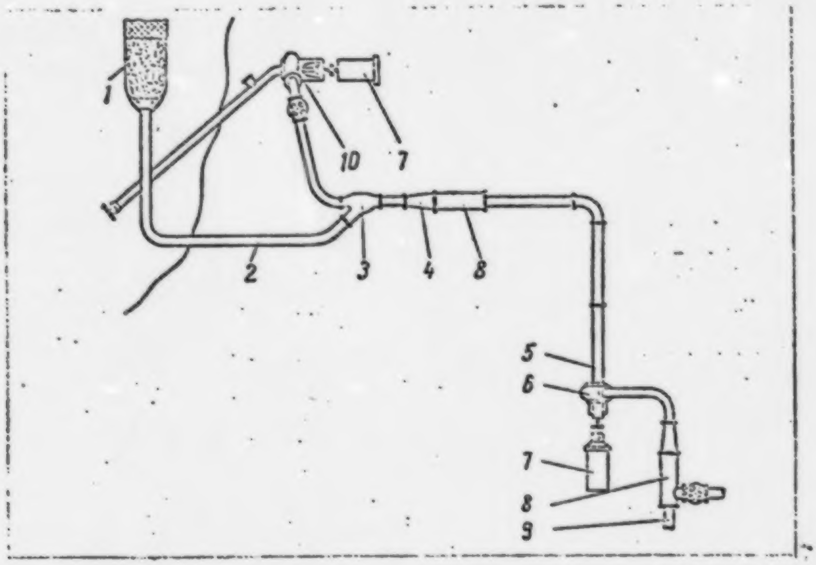


Figure 45 - Diagram of a combined two-stage water-jet centrifugal fish-pumping unit:

1 - trap; 2 - fish-receiving conduit; 3 - mixer of NCh-3 fish pump; 4 - diffuser of NCh-3 fish pump; 5 - intake conduit for RB-250; 6 - RB-250 fish pump; 7 - ZIS-120 engine; 8 - water separator; 9 - fish delivery conduit; 10 - centrifugal pump for NCh-3 fish pump.

Therefore, after [having passed through] the RB-250 fish pump, the surplus water was drained from the separator through a special regulating valve. It was owing to this that after [passing through] the water separator, a much smaller volume of the mixture of fish and water moved through the fish delivery conduit, retaining the normal speed of movement of the mixture (1.2 to 1.4 m/sec), which, in turn, kept the quality of the fish at its best during conveying. The length of the fish conduit in the unit that we have described was 710 m, with a geometric difference of 5 metres in the elevations of the beginning and end of the conduit.

The fish conduit terminated in an open water separator at a fish receiving platform. The fish, which had been freed of water in the /134 water separator, rolled down an inclined grating and were directed alternately to one of the measuring bins. While one bin was being filled, the fish were received by an inspector at another bin, from which they were removed.

Fish remains were washed from the bottoms of the bins with a jet of water from auxiliary canvas hoses 150 mm in diameter. The hoses were connected to the water separator, from which the surplus water was removed to the river through a canvas hose 250 mm in diameter.

The fish passed through the entire 710-m-long fish conduit in an average of 10 minutes. During the period of peak loading of the fish pumps, the average time taken to fill a bin with a capacity of 5 centners (500 kg) was 4.75 minutes. During the 1951 fishing season this unit pumped 27,955 centners (2,795,500 kg) of live fish through pipes.

The application of this unit was highly effective. Fishing crews serviced by fish pumps began fishing with two seines and had an opportunity to increase their catches by 130 to 150%, with less physical labour, as compared with other crews not serviced by fish pumps. The quality of the fish turned in by crews serviced by pumps was higher than that of the fish from catches by other crews, since the fish caught by the former crews was delivered immediately by fish pumps to the fish-receiving platform. Moreover, self-propelled and non-self-propelled vessels proved to be unnecessary for servicing the crews [provided with fish pumps], and they were transferred to other crews in order to accelerate the latter's work.

When a crew had caught fish during the period of the latter's run in the river, and had quickly pumped the catch with fish pumps, it rested, having worked 9 to 10 hours a day, while the other crews, not serviced by fish pumps, remained in order to load the catch into kungasy and deliver it to the fish combine.

This pump unit also worked successfully during the 1952 fishing season and pumped 26,426 centners [2,642,600 kg] of salmon.

In 1953 combined fish-pumping units and fish conduits were installed at three fishing places of the Krasnyi Truzhenik Collective Establishment and pumped a total of 46,400 centners [4,640,000 kg] of salmon to the fish filleting plant of the Ozernovskii Fish Combine. Fish conduits were laid for distances of 830, 969, and 1,164 metres in the direction of a new fish filleting plant.

At the Anapkinksii Fish Combine a combined two-stage unit including the NCh-3 and RB-250 fish pumps was mounted on a kungas with a cargo capacity of 25 tons.

A diagram of the combined NCh-3 and RB-250 unit, which worked in 1953 and 1954 at the Anapkinskii Fish Combine, is shown in Fig. 46. The first-stage NCh-3 fish pump is operated by a centrifugal pump, which draws in pure water through a hose thrown over the side of the kungas. Water is fed through a starting valve into the nozzle of the NCh-3 fish pump and creates a vacuum in its working chamber.

The intake hose of the NCh-3 fish pump is lowered with a ship's /135 boom into a kungas containing fish. The mixture of fish and water that is drawn in by the NCh-3 fish pump passes through a closed water separator and is conveyed to the intake opening of the RB-250 fish pump. The latter pumps the mixture of fish and water further into the fish delivery conduit. Since [in this instance] the conveying was carried out for a distance in excess of 100 metres, a second water separator was set up on the fish delivery conduit in order to remove surplus water, which reduced the flow rate through the cross section of the pipe, as well as resistance and pressure head losses.

Part of the water from the first water separator returns through the flooding hose to the fishing kungas that is being unloaded, in order to maintain a normal concentration of the mixture of fish and water at the time of unloading. In addition, water is added to the mixture within the NCh-3 fish pump: it enters the mixing chamber from the nozzle for

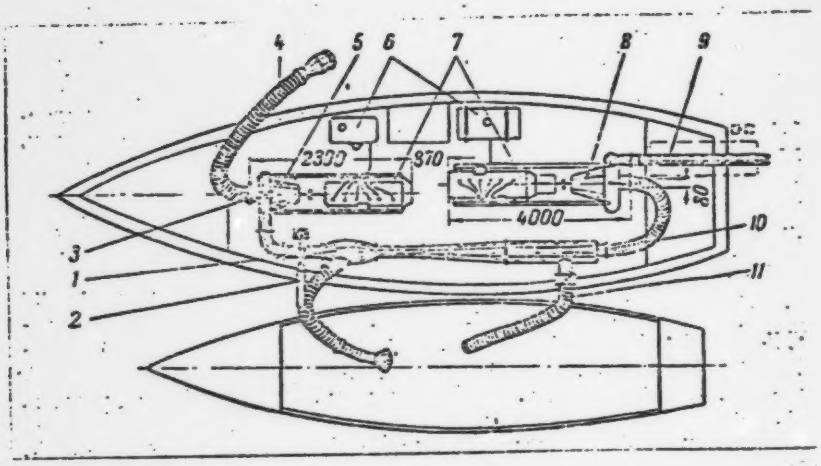


Figure 46 – Combined two-stage water-jet centrifugal fish-pumping unit on a kungas:

1 – NCh-3 fish pump with an intake hose; 2 – boom and winch; 3 – valve; 4 – water intake hose; 5 – centrifugal pump; 6 – gasoline tanks; 7 – ZIS-5 engine; 8 – RB-250 fish pump; 9 – fish delivery conduit; 10 – water separator; 11 – flooding hose.

---

operating water. The fish-and-water mixture, therefore, enters the RB-250 evenly and sufficiently diluted with water.

In the event that there is an inrush of air into the intake hose, the air does not disrupt the operation of the NCh-3, but rather passes into the first closed water separator and escapes through the flooding hose without reaching the RB-250 and disturbing its operation.

The discharge of the unit has ranged from 300 to 480 centners [30,000 to 48,000 kg] of herring per hour. A mixture with a ratio of 1:1 was created when the combined unit operated in a *kungas* that was being unloaded. Where the conveying distance was more than 100 metres, the unit fed a mixture of water and fish directly into a hydraulic conveyer to a height of 7 metres. Here both fish pumps (the NCh-3 and the RB-250) /136 of the unit operated at below-normal rpm's: the NCh-3 centrifugal feeding pump, at 1,072 rpm, and the RB-250 fish pump, at 308 rpm. Where necessary, the height to which the unloaded fish were lifted could be increased. For this purpose, it was necessary to bring the rpm's of both fish pumps up to normal (1,500 and 400 rpm).

On the *kungas* on which both fish pumps and their engines were mounted, there was a work bench, fuel tanks and a compartment where the attendants could rest. In the combined unit the herring passed through two fish pumps. In spite of this, under equal operating conditions the extent of mechanical injury to the fish in this unit was less than in unit's higher one RB-250 fish pump for unloading herring from *kungasy*.

The operation of the combined unit was very steady owing to the absence of the harmful influence of air in the mixture of water and fish. This explains the unit's higher discharge as compared with that of single-stage fish pumps of type RB-250, which had worked under the same conditions with a combined unit at the Anapkinskii Fish Combine in 1954.

The advantage of a combined two-stage unit including fish pumps of types NCh-3 and RB-250 is its capacity for unloading both kungasy and net frames. A flooding pump is required for unloading kungasy with a fish pump of type RB-250. A separate engine is necessary in order to operate the pump for flooding the kungasy.

There is no doubt that the mounting of two fish pumps and two motors on one kungas increases the cost of the unit and makes it more unwieldy. Additional inconvenience is also created for the attendants. These inconveniences, however, are less than those created during the operation of an RBU-250 unit mounted on a single kungas together with a flooding pump.

The fuel consumption per centner [100 kg] of fish unloaded in a two-stage combined unit (81.2 grams per centner) is less than in a single-stage RB-250 unit with a pump for flooding (99.5 grams per centner). This is explained by the fact that although 35 to 40 horsepower, i.e., almost the same amount of power as for the flooding pump, are required for operating the NCh-3 fish pump, in the combined unit the pressure head created by the NCh-3 fish pump is added to that developed subsequently by the RB-250 fish pump when it is switched on; in this arrangement, there is an increase in the useful height to which the unloaded fish is raised. In the single-stage RB-250 unit, on the other hand, the power consumed by the engine for operating the pump that is to pour water into the kungas, is not used for the useful work of lifting the mixture of water and fish.

As operational practice has shown, where unloading is performed with a combined unit, very little water and virtually no fish remain in a fishing kungas. When an NCh3 fish pump is installed in the first stage, work is permitted with a thin layer of water (9 to 10 cm) in the kungas. /137

When the RB-250 fish pump is used for unloading, after the work is completed a 25- to 35-cm layer of water remains in the kungas, along with 1.5 to 2 centners of fish, which workers then remove by hand.

If the residual layer of water is less than 25 cm, air begins very frequently to rush into the intake hose, and the fish pump will spontaneously cease productive work. When a kungas is unloaded with a fish pump of type NCh-3, air rushing into the intake hose does not cause the fish pump to shut down spontaneously. The less water remains in the kungas, the fewer fish remain unloaded.

Kungasy in which a finished poel[☆] is laid above the

☆ Translator's note. See Translator's note, p 113.

timbers, and a hatch is left in the bow part of the hold, are cleared with particular thoroughness by a fish pump. In kungasy of this kind the fish move easily along the smooth poel to the snore piece of the fish pump together with the flooding water, which accelerates the unloading. When such kungasy are cleared, fish do not remain between the timbers as they do in kungasy where finished poel's have not been laid.

Among the positive features of the work of a combined unit of NCh-3 and RB-250 fish pumps should also be included the absence of a snore piece on the intake hose, which facilitates maneuvering of the latter both in the process of unloading fish from a kungas and during breaks in the work, when an unloading kungas is replaced by one that has not yet been unloaded.

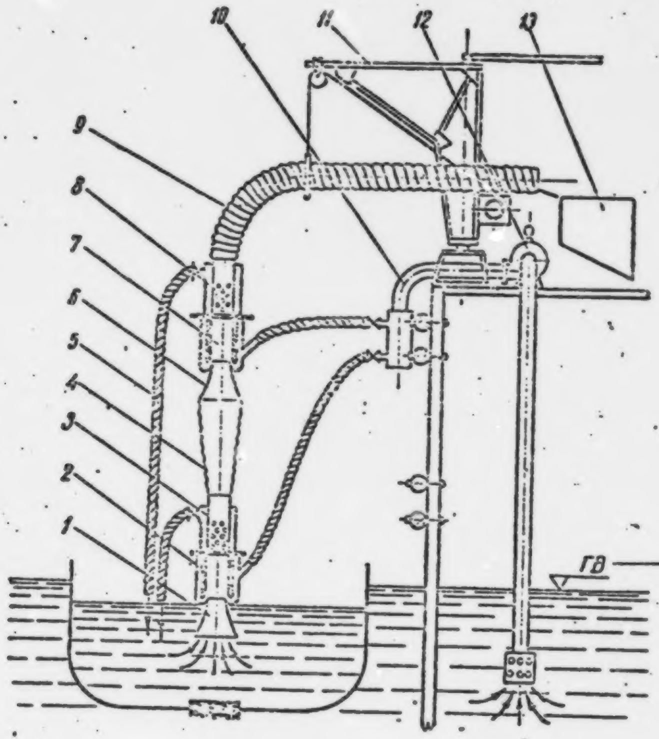
During temporary interruptions in the work of a combined unit, the fish pumps can continue to work with a reduced number of revolutions. Pure water is fed to the RB-250 through the nozzle of the NCh-3 fish pump. In the process, the fish conduit is flushed with pure water without an interruption in the work, which is of great importance in conveying a mixture of water and fish through pipes for considerable distances. Cessation of the operation of the fish-pumping unit for even a short time stops the movement of the water-and-fish mixture through the entire length of the fish conduit. When the fish-pumping unit is subsequently started, the creation of a higher pressure head is required at the beginning of the fish conduit in order to overcome the inertia of the entire quantity of the mixture of water and fish that is in the pipes. Moreover, stopping the movement of a mixture of water and fish in a long fish conduit can cause the fish to stratify in some area of the conduit (a bottleneck). A prolonged shutdown of work and dismantling of the fish conduit at the place where the bottleneck has formed are required in order to eliminate the obstruction.

The Two-Stage EKR-2 Fish Pump

The EKR-2 two-stage water-jet fish pump has been proposed by I.V. Nikonorov. This proposal reflects an attempt to bring together both stages in two-stage pumping (which has been realized in the NCh-3 - RB-250 unit) and to combine them /138 in one unit, which will make servicing considerably cheaper and easier.

The EKR-2 unit (see Fig.47) has been proposed in the form of a flexible structure suspended from a crane hook. It consists of two EKR-1 water-jet devices (ejectors) connected in sequence with an annular feed of operating water. The ejectors are connected to each other with flexible cone-shaped hoses.

Operating water is supplied to both devices from a /139 stationary centrifugal pump standing on a wharf through a manifold with regulating valves.



GV [expansion not available]

Fig. 47 - Line diagram of the EKR-2 two-stage water-jet fish pump:
1 - intake spout of first-stage fish-pump;
2 - first-stage ejector with annular delivery of operating water;
3 - closed diffuser of first-stage fish pump;
4 - specially designed dilating hose;
5 - hose for delivering water into a ship from a return diffuser;
6 - intake spout of second-stage fish pump;
7 - second-stage ejector;
8 - closed diffuser of second-stage fish pump;
9 - delivery hose of second-stage fish pump;
10 - delivery hose of centrifugal pump and manifold for operating water;
11 - maneuvering crane;
12 - centrifugal pump;
13 - receiving devices for fish.

After each ejector is placed a closed diffuser-water separator, where part of the water is drained off from the fish pump into the ship that is being unloaded or into the body of water. On each diffuser there is a regulating valve for controlling the discharge of water.

Although this unit has not been produced, this proposal is of considerable interest.

4. Prospects for Developing Designs of Multistage Fish Pumps.

The multistage pumping of fish represents an urgent necessity for the fishing industry. It is needed not only in individual cases, at single fish plants, but also in entire vast regions, for example, in areas of the Okhotsk coast, the western coast of Kamchatka, shallow regions of the Caspian, at a number of fish plants located on steep shores in the Azov-Black Sea area, and at enterprises that have no outlet to a wharf line (canning plants at Yalta, Mamonovo and other places).

The two-stage pumping of fish was at first carried out with two completely detached fish-pumping units. In this arrangement, the second-stage fish pump was placed at the end of the fish conduit leading from the first-stage fish pump at the precise spot where the pressure head created by the first-stage fish pump was almost completely spent.

A tendency subsequently appeared in the two-stage pumping of fish to bring both stages together and to combine them into a single unit. Under this arrangement, the work involved in the two-stage pumping of fish was immensely facilitated; the number of workers servicing the unit was reduced; the interaction of both stages was facilitated, and, as practice has shown, the range of the fish pumps and the height to which the fish were conveyed were sharply increased: the conveying range reached 1,100 metres, with a delivery height of 24 metres.

Three-stage units then appeared.

The next step on the path of development of the two-stage pumping of fish should be the transition from two-stage fish-pumping units to a two-stage fish pump, i.e., to a single machine with two stages of pressure head - in water pumps and in compressors.

With the transition to the two-stage fish pump, the consumption of metal will decrease, greater use will be made of the power of the engine, and power consumption will drop. The replacement of single-stage by two-stage fish pumps will permit inclined scraper conveyers, which move fish into hydraulic pan conveyers, to be excluded from plans for hydraulic mechanization on Sakhalin and in Kamchatka and other regions.

Inclined scraper conveyers built into hydraulic mechanization systems represent an area where fish are constantly injured. Fish are spilled at their inlets and outlets, with accompanying mechanical injury to the fish and the resultant formation of heaps of fish on the ground, owing to which their quality is reduced. Therefore the elimination of inclined conveyers by the introduction of two-stage fish pumps will considerably improve the work of hydraulic engineering systems at fish plants. /140

It is also advisable to develop the design of a three-stage fish pump.

When designs are developed for two-and three-stage machines, these machines must be provided, as regards primary intake, with devices which will permit the elimination of a return valve at the end of the intake hose and which will make the fish pump as a whole insensitive to the entry of air into its inner cavities. It is evident that such a device will be an ejector attachment on an intake pipe with annular delivery of operating water.

The designing of two- and three-stage fish pumps should evidently be proceeded or accompanied by a review of the theory of the operating process in a fish pump, with development of the problem of the effect of accelerations in the pump on conditions for the safety of fish both in the fish pump itself and in the fish delivery conduit.

Finally, a further step in the development of fish pump designs should be the creation of multistage fish pumps whose range would amount to 5 or 6 kilometres, which in a number of cases is necessary.

Chapter VI

HYDROPNEUMATIC FISH-PUMPING UNITS

1. The KRCh-1 Fish-Pumping Unit

Water-jet and centrifugal fish-pumping units that have /141 been used in industry have a number of intrinsic drawbacks, toward the elimination of which the efforts of Soviet hydromechanics specialists have been directed.

Since, in pumping with modern fish pumps, the ratio of the quantities of fish and water is 1:10, a large amount of water is pumped together with the fish, which causes a considerable consumption of power in unloading and conveying the fish.

The model sizes of fish pumps are selected depending only upon the dimensions of the fish that are being pumped. At the same time, the discharge of a fish pump is a function of its dimensions. Fish pumps, therefore, consume power irrespective of their fish discharge. It is not possible to reduce the normal water discharge (for example, in fish pumps of the RB type) together with a simultaneous and proportional reduction of power, not to mention a reduction in the constructional dimensions of the fish pump. Hence at a large number of commercial fish enterprises that receive only a small quantity of fish daily, the use of centrifugal fish pumps is inefficient because the coefficient of use of the powerful equipment is too low. The limited intake height of existing fish pumps does not permit the unloading of fish from fishing gear, kungasy or net bags at the roadstead in order that the equipment of a fish pump unit might be located on shore safe from storms and waves. At the same time, the cost of floating roadstead units is very high, since to the cost of the equipment of the fish-pumping unit is added the cost of the ship necessary for installing this equipment.

In centrifugal fish pumps, which are the most widely used, the entry of air into the intake hose disrupts the normal operation of the pump; a heavy snore piece and a hose filled with water hamper maneuvering during unloading; priming the pump before beginning work hinders the starting of the fish pump - all of this complicates the operation of a fish-pumping unit.

The attempt to eliminate the above shortcomings of water-jet and centrifugal fish pumps has led to the development of new designs and systems. /142

The Mechanization Laboratory of the Kamchatka Division of TINRO has developed the new KRCh [which expends to] (Kamchatka Fish Pump, Chernigin System). The fish pump (see Fig. 48) consists of a chamber within which slowly turns a rotor that has seven radially arranged sections.

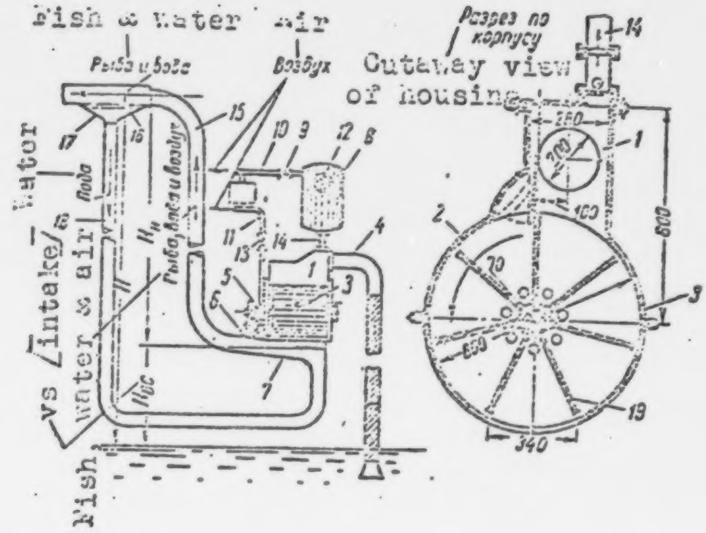

Fish & water
Рыба и вода
Air
Воздух
Разрез по корпусу
Cutaway view of housing
Water
Вода
Hвс
Intake/m
Fish
Water & air
Hн
Рыба, вода и воздух
17
16
15
10
9
12
8
11
13
14
4
1
3
5
6
7
2
70
280
200
100
800
650
340
19

Fig. 48 - Diagram of KRCh-1 fish-pumping unit:

1 - receiving chamber; 2 - KRCh-1 housing;
3 - opening for air by-pass; 4 - intake pipe;
5 - reducing gear; 6 - platform for electric motor;
7 - fish receptacle; 8 - receiver; 9 - regulating valve;
10 - outgoing air conduit; 11 - air delivery conduit;
12 - vacuum gauge; 13 - valve; 14 - branch pipe;
15 - pipe for raising mixture of water, fish and air;
16 - grating; 17 - water separator; 18 - pipe for returning water to receptacle;
19 - rotor of fish pump.

To the chamber is connected a pipe for drawing in the mixture of water and fish, a pipe for pumping air out of the chamber, a pipe for supplying compressed air, and a receptacle for the fish discharged from the chamber.

Air is pumped out of the upper part of the chamber through the receiver by a vacuum pump, and compressed air is fed to the lower part of the chamber. The rotor and its radial fins, equipped with a special packing, come into close contact with the walls of the chamber and slide along the inner surface*. Thus the fins of the chamber separate the intake zone, with its vacuum, and the compressed air feed zone.

The fish receptacle is connected to a vertical pipe which at its other end opens onto a water-separator grating with a pan. The latter is connected to the receptacle by another pipe.

The receiver is designed for reducing the fluctuations /143 in pressure in the upper part of the chamber, which are unavoidable because of the escape of air from the compressed air zone.

The air that is drawn from the KRCh is not discharged into the atmosphere, but rather enters the compressor, is compressed by it to the corresponding pressure, returns through a regulating valve to the side cover of the housing and enters the next section that has come up for unloading. Openings are made in the cover of the housing and in the end walls of the rot

---

[*] Translator's note. The term "surface" is here used as an equivalent of the Russian obrazuyushchaya, an adjective meaning, literally, "forming".

Compressed air is released into the lower chamber when the openings in the side walls of the housing and the rotor coincide and the wall of the rotor is placed above the open aperture of the receptacle.

Inspection windows are installed in both the chamber and the receptacle for observing the processes taking place in these areas.

The KRCh rotor is rotated by a 2.8-kw electric motor through a reduction gear.

In 1951 an experimental KRCh model mounted as shown in the diagram in Fig. 48 was tested at the *Mokhovaya* Fish Plant for unloading cod, flounder and walleye pollock from *kungasy*, and lifting these fish 13 metres.

The mixture of fish and water entered the chamber through an intake pipe; within the chamber, the fish became packed lengthwise in the sections of the rotor. The rotor transferred the unloaded mixture into the receptacle; at the same time, the compressed air fed into the chamber helped to expel the mixture from the rotor chamber into the receptacle. Compressed air, which had been fed with a certain surplus, partially entered the receptacle together with the mixture of water and fish. The surplus compressed air served as a source of energy for the uninterrupted circulation of water in the system of communicating pipes connected to the water separator and its pan.

The air, entering the right-hand pipe, formed, with the fish and water, a mixture with less density than water. At the same time, the left-hand pipe was filled with water and together with the right-hand pipe formed a system of communicating vessels, in which by virtue of the difference in the density of the contents of both pipes, a constant movement (circulation) was established: the water from the left-hand pipe expelled the lighter mixture from the right-hand pipe. As a result of this movement, a mixture of air, water, and fish poured out continually onto the upper grating, where the mixture was separated: the water flowed off through the grating into the pipe and filled it, the fish rolled down an incline into the trough of the hydraulic conveyer, and the air escaped into the atmosphere.

Since an extremely small difference in the heights of the column of mixture in the pipe 15 and of the column of water in the pipe 18, equal to approximately half the diameter of the delivery pipe 15, had to be overcome, a very small quantity of compressed air was required for operating the system. Part of the pressure head was consumed on overcoming friction in the movement of the mixture of /144 water and fish in the pipes, and on overcoming the inertia of the fish and water in the receptacle.

An entirely fixed quantity of water circulated in the system of the pipes 15 and 18; all of the water that emerged once more from the chambers of the rotor was discharged above the grating of the water separator and helped the fish to move through the hydraulic conveyer.

The circulating water moved through a pipe up into the part of the receptacle opposite the place where the fish passed from the chamber of the rotor into the receptacle, and further on into the pipe 15. This helped the fish to move from the receptacle into the pipe 15.

Under the effect of the movement of compressed air and water, the fish upon emerging from the chamber into the receptacle assumed an oblique position, which facilitated their unimpeded passage from the chamber into the receptacle and into the pipe 15. This occurrence was observed through the inspection windows in the receptacle.

In tests, the height to which the fish were raised was 15 metres: the intake height was 6 metres and the lift was 9 metres. Actually, the intake height was 7 metres, since the fish were at first drawn in to a height of 7 metres when they were taken to the chamber, and were then lowered by the rotor to a height of 6 metres above sea level. Under these conditions, 2.8 kw were consumed on operating the rotor, and about 30 kw on the work of the compressor - a total of 32.8 kw.

During the first tests, flounder, cod and walleye pollock unloaded from a kungas were pumped. The tests demonstrated that virtually no injury to fish occurs in the KRCh unit. Exceedingly important was the fact that for the normal intake of a mixture of water and fish into a KRCh it was required to dilute the mixture to a consistency several times less than [that required] when [a mixture of fish and water] was drawn into the NCh-3 or RB fish pumps. During the tests, the composition of the mixture of water and fish reached 1:3 to 1:4.

Further work with the KRCh-1 fish pump was directed towards improving the chamber and the rotor and on ensuring the tightness of the union of the inner surface of the chamber with the radial fins of the rotor. It was required to secure the tightness of a sliding junction on a diameter of 800 mm, which proved to be a fairly difficult task.

Originally, the housing of the chamber (see Fig. 48) had in its upper part a special projection, near which was fastened a plate made of conveyer belt. The plate threw off into a section fish that happened by chance to be on a fin of the section, and thereby prevented damage to the fish from its being jammed between the fins and the wall of the housing.

A change has subsequently been made to another shape of chamber (see Fig. 49), whose housing consists of a cylinder with a smooth interior. A rotor revolves in the housing. On the fins of the rotor are bronze sealing plates.

In the upper part of the housing is placed a branch pipe, through which air is continually drawn out of the /145 receiving part of the chamber with the aid of a vacuum-air pump.

In the wall of the receiving chamber is an opening through which a mixture of fish and water moves into the chamber and onto the rotor. The entry of the mixture is monitored through inspection windows.

Under the force of gravity the mixture of fish and water settles in a section of the rotor, which revolves, impelling the fish. If the entry of the mixture into the chamber must be quickly stopped, the intake is shut off manually with a special gate. The KRCh is started and stopped and its discharge regulated with the aid of a valve installed on the branch pipe for drawing off air. The diameter of the branch pipe is 75 mm. By opening the valve, we increase the speed with which air is drawn out of the chamber and thereby increase the vacuum. The greater /146 the vacuum maintained in the receiving chamber, where the intake height is constant, the more fish-and-water mixture will enter.

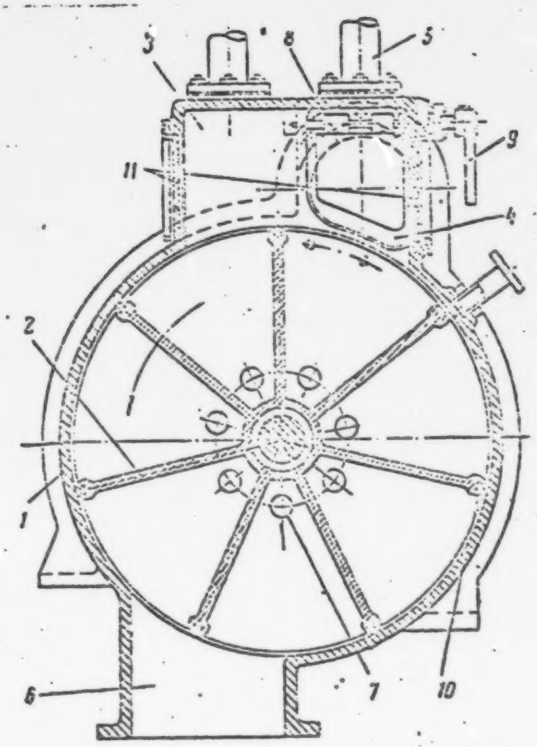


Figure 49 - Improved chamber of KRCh-1:

1 - chamber housing; 2 - rotor; 3 - receiving section; 4 - pipe for drawing in mixture of water and fish; 5 - branch pipe for drawing off air; 6 - branch pipe for outflow of water-and-fish mixture; 7 - openings for feeding compressed air; 8 - safety valve; 9 - handle; 10 - packing on fins of rotor; 11 - inspection windows.

The speed at which the rotor rotates is taken as equal to 5.6 to 6.5 rpm. This speed has been specially selected so that each chamber will not be filled entirely, which will prevent the fish from becoming jammed between the fins and the housing when the gate rotor* revolves. In a chamber that is not full, the fish become packed along it and do not project out beyond the edge of the fins.

In order to improve conditions for the "self-packing" of fish in the rotor chamber, the delivery opening is shifted, in relation to the centre of the rotor, in a direction opposite to the rotation.

In the lower part of the housing is an opening through which the mixture of fish and water is removed from the next chamber of the rotor when it is rotating in the direction indicated by a pointer. The fish-and-water mixture is removed freely if the fish is delivered directly to the fish-receiving platform. If the fish that is being unloaded must be raised to some further height, the mixture of water and fish is removed with compressed air fed through openings in the walls of the housing and the rotor into a special receptacle and further on up the pipes.

---

* Translator's note. The term "gate rotor" is used here and elswhere in this chapter as an equivalent of the Russian rotor zatvora. Zatvor is a Russian word whose meanings include (among others) "closing device", "gate", "valve", and "(liquid) seal". The manner in which the term "gate rotor" is used in the original text tends to create some ambiguity, but since throughout the description of the KRCh-1 unit only one rotor is mentioned, it will have to be assumed that the "gate rotor" and the rotor of the KRCh-1 are one and the same. The modifier "gate" may possibly refer to the closure that exists between the radial fins of the rotor and the inner surface of the chamber.

The KRCh was tested in 1954 on unloading salmon from a net bag on a floating frame located in a roadstead at a distance of 120 metres from the shore. The fish was conveyed only to the receiving platform without additional lift. During the test, all of the equipment of the KRCh unit was safe on shore. Only the fish intake conduit was in the sea. The total quantity of fish unloaded by the KRCh fish pump during these tests was not large (11.5 centners /1,150 kg7 of pink salmon, sockeye and chum), but all of it was unloaded without damage and was conveyed to the fish receiving platform live. The ratio of fish to water was 2:1 to 3:1.

In Fig. 50 is shown an overall view of a KRCh-1 unit mounted on an RKZ-59 fish-receiving platform. On the left is an electric motor, which rotates the gate rotor with a belt drive and a reducing gear. At the rear of the KRCh housing is a receiver, and on the right, a vacuum-air pump which is operated by a 45-kw electric motor. The actual power consumed by the vacuum-air pump during these tests, according to instrument readings, amounted to 16 to 18 kw. The vacuum in the chamber was maintained within the range of 450 to 460 mm of a column of mercury.

Below, under the housing of the KRCh, is the grating of the water separator. The longitudinal axis of the KRCh housing is inclined towards the sea in order best to fill the chambers and to facilitate the discharging of the fish.

Live fish and water move from the lower opening of the KRCh housing to the platform.

Tests of the KRCh have yielded encouraging results, and will subsequently be continued, with the introduction of certain improvements into the design of the unit. /147

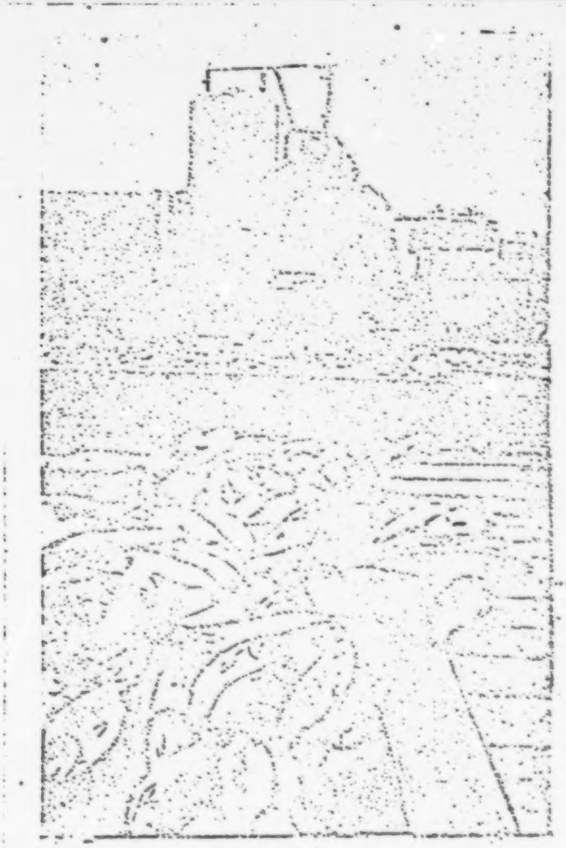


Figure 50 - General view of KRCh-1 unit at Fish Cannery No. 59 of the Chief Directorate of Commercial Fishing in Kamchatka /Glavkamchatrybprom/.

A second KRCh fish pump was tested in 1954 at the Mokhovaya Fish Plant of the Avacha Fish Combine, Chief Directorate of Commercial Fishing in Kamchatka [Glavkamchatrybprom]. The fish pump was mounted on a fish-receiving platform for unloading flounder and cod from kungasy brought directly up to the platform. In this unit the length of the intake hose was 9 metres, and the height to which the unloaded mixture was raised was 4.5 metres.

The tests demonstrated the possibility of unloading from kungasy, with the aid of KRCh, mixtures of water and flounder with ratios of 1:1 to 2:1. In this instance the discharge of the KRCh reached 20 to 25 tons of fish per hour. The vacuum-air pump was operated by a 20-kw electric motor. The actual power consumption was not measured. /148

The power consumed by the electric motor rotating the KRCh rotor was a maximum of 0.5 kw (from instruments).

At the Mokhovaya Fish Plant it has subsequently been proposed to carry out an experiment on unloading flounder with a KRCh directly from the holds of trawlers in port. Since it is not desirable to flood the holds of trawlers, the intake hose of the KRCh will be equipped with a combined head [attachment], according to the principle of similar devices on centrifugal fish pumps, which will permit the flooding of the hold with water to be almost completely avoided.

Two-stage air compressors of type 200-V-10/8 with a discharge of 10 m^3 of air at a pressure of 8 atmospheres have been used in KRCh units as vacuum-air pumps.

A compressor converted to a vacuum-air pump had a low efficiency, was unwieldy, and could give a vacuum of no more than 80%. Soviet industry is now manufacturing rotary compressors that are less cumbersome, highly efficient and capable of providing a vacuum of up to 95%. When such vacuum-air pumps are used, the consumption of power by the KRCh-1 will decrease considerably, the intake height will be increased, and maintenance will be simplified.

The tests that have been carried out have not fully characterized the work of the KRCh-1; nonetheless, some advantages of this unit have already been revealed. Such advantages include: a considerably lower power consumption per ton of pumped fish; the possibility of raising unloaded fish to a height of up to 15 metres with a one-stage unit containing the KRCh-1 fish pump; a good intake height (up to 7 metres), permitting ships and net frames to be unloaded in a roadstead with location of the fish pump equipment on shore and without the creation of a roadstead floating unit on a kungas, and the possibility of working with a fish content of up to 75% in the mixture without any damage whatever to the fish.

As may be seen from results of tests of the KRCh-1, a wide range of discharge in unloading helps to increase the economy of a unit. The possibility of regulating the discharge permits the effective use of the KRCh-1 at fishing industry enterprises taking in less than 1,000 centners [100,000kg] of fish per day.

Among other features of the KRCh-1 unit is the absence of a valve at the end of the intake hose, which permits the elimination of preliminary priming. In addition, the fish pump does not stop working when air gets into it.

The tests have also revealed some shortcomings of the KRCh: the awkwardness of the unit, particularly in connection with the necessity for using a vacuum-air pump; the complexity of machining the KRCh-1 housing (its diameter is 800 mm); the difficulty of securing the tight fitting of the rotor fins to the housing and the complexity of /149 repairing the vacuum-air pump.

2. Calculations for the Basic Elements of the KRCh-1 Unit

For the purpose of making calculations for elements in the design of a KRCh-1 fish-pumping unit we assume that large fish (salmon) will be pumped which must be conveyed either to the platform of a wharf (when the fish-pumping unit is working only on intake), or above the platform to a hydraulic conveyer (when the fish-pumping unit is working on intake and delivery).

Technical Description of KRCh-1 (preliminary)

Maximum length of pumped fish, in mm	800
Discharge of water, in m^3 per hour	75
Discharge of fish, in tons per hour (supposed)...	30 to 40
Height to which mixture of fish and water is drawn in, in m*	up to 6
Height of additional lift, in m	9
Level of centre of intake opening, in m	7
Rpm of rotor	5.5 to 6.5
Power consumed by electric motor of vacuum-air pump in relation to lift, in kw	18 to 30
Power consumed by rotor motor, in kw	1.0
Discharge of vacuum-air pump in m^3/minute	12
Volume of receiver, in m^3	1
Diameter of intake hose, in mm	250

---

* Translator's note. The unit given in the original text was millimetres (mm), which does not appear at all reasonable and is believed to be a misprint.

Proceeding from the condition that large fish "pack themselves" in the rotor chamber, we assume that the length of the fish $l_r = 750$ mm, in conformity with the maximum length of the ordinary commercial species of fish.

From these considerations we assume that the diameter of the rotor $D = 800$ mm, the length of a section of the rotor $l = 800$ mm, and the number of chambers $z = 7$.

In this instance the central angle formed by the fins of the drum will amount to

$$\varphi = \frac{360}{7} = 51°26'.$$

The full volume of a sector

$$S_1 = \frac{\pi D^2 l}{4z}; \qquad [61]$$

$$S_1 = \frac{3,14 \cdot 8^2 \cdot 8}{4 \cdot 7} = 57,4 \text{ дм}^3. \text{— dm}$$

By subtracting the volume occupied by the fins and the hub of the drum, we obtain the useful volume of a sector

$$S_n = 57,4 - 0,2 \cdot 8 \cdot 4 = 51 \text{ дм}^3. \text{— dm}$$

In order to ensure the safety of the fish, the sectors of the rotor should be filled with a mixture of fish and water only to 65 to 70% of their volume. Then the working volume of a section will amount to /150

$$S_n' = \psi S_n, \qquad [61a]$$

where: ψ is the space factor, which we assume is equal to 0.67;

$$S_n' = 0,67 \cdot 51 = 34 \text{ дм}^3. \text{— dm}^3$$

Assuming that the content of fish in the mixture $i = 80\%$, we determine the quantity of fish S_r carried off from the chamber by each sector

$$S_{\underset{r}{р}} = S'_{н}\, i = 34 \cdot 0{,}8 \cong 27\ \underset{dm}{дм^3},\ \underset{or}{\text{или}}\ 27\ \underset{kg}{кг}.$$

In order to ensure a discharge equal to Q_{r_1} = 60 tons per hour, the rotor should have the following rpm

$$n = \frac{Q_{р_1} \cdot 1000}{60\, S_р z}; \qquad [62]$$

$$n = \frac{60 \cdot 1000}{60 \cdot 27 \cdot 7} = 5{,}3\ об/мин.\text{— rpm}$$

In order to ensure the free passage of fish in the intake hose, we assume that its diameter d_{sh} [hose] = 250 mm; then the speed v of the movement of the mixture in it will be

$$v = \frac{Q_{р_1}}{i\,\frac{\pi d_{ш}^2}{4}\,3600}; \quad \text{ш — sh [hose]}$$

$$v = \frac{60 \cdot 100 \cdot 4}{80 \cdot 3{,}14 \cdot 0{,}25^2 \cdot 3600} = 0{,}425\ м/сек.\text{— m/sec}$$

In view of such a low speed of movement of the mixture, there is no need to fear damage of fish in the intake hose. We shall disregard losses on friction in view of the low speed of movement and the short length of the hose. (L_{sh} [hose] $\cong$ 8 m).

In order to deliver the fish to a platform raised H = 6 m above the level of the body of water, the fish must be raised to an estimated height H_r = 7 m.

In order to ensure the raising of the fish to such a height, it is necessary that the vacuum pump remove all air entering the chamber and maintain pressure in it.

$$p_1 = p_a - H_p; \qquad [63]$$

$$p_1 = 10,33 - 7 = 3,33 = 0,33\ \overset{\text{atm}}{\text{атм}} = 3330\ \text{кг/м}^2 - \text{kg/m}^2.$$

When the drum revolves, air must be removed from the gate; in calculations, the quantity of this air must be considerably increased (allowing for inleakages through clearances and loose connections). /151

When air is pumped out with a vacuum-air pump, in the same way as when it is compressed, processes of air expansion can take place according to certain laws of thermodynamics; along an isotherm, i.e., where the temperature is constant; along an adiabatic curve, when the atmospheric temperature changes, or along an intermediate - polytropic - curve. It is known from thermodynamics that work in the case of an isothermic change in the state of gases is always less than where the change is polytropic or adiabatic.

Allowing for this, when we proceed to calculate the discharge of a vacuum-air pump, we assume that the processes of expansion of air, when the latter is pumped from a chamber, take place isothermically; when we calculate the power consumed by a vacuum-air pump, we assume that the processes of the change in the air in the pump take place adiabatically.

We calculate the free volume of air in each sector from the difference of the useful volume of the sector and the volume of that part of it which is filled with the mixture of fish and water

$$q_n = S_n(1-\psi), \qquad [64]$$

where: $\psi = 0.67$ is the space factor;

S_n is the useful volume of a section in cubic decimeters.

In this case, the discharge of a vacuum-air pump, where there is isothermic expansion, and without allowing for inleakages of air, will amount to

$$q_1' = S_1(1-\psi)zn\frac{p_a}{p_1}, \qquad [65]$$

where: $z = 7$ is the number of sections in the rotor;

$n = 5.3$ is the rpm of the rotor;

$p_a = 10.33$ m of a column of water is the atmospheric pressure;

$p_1 = 3.33$ m of a column of water is the pressure in a section of the rotor (in the chamber);

$$q_1' = 0{,}051\,(1-0{,}67)\,7\cdot 5{,}3\,\frac{10{,}33}{3{,}33} = 1{,}9 \text{ м}^3/\text{мин} - \text{m}^3/\text{min}$$

Allowing for inleakages of air, we increase the discharge of the vacuum-air pump by approximately 3.5 times. Then the estimated discharge of the vacuum-air pump, when the fish-pumping unit is working only on intake, will amount to

$$q_1 = 3{,}5\,q_1' = 3{,}5\cdot 1{,}9 \cong 6 \text{ м}^3/\text{мин} - \text{m}^3/\text{min}$$

The power consumed by a vacuum-air pumpduring an adiabatic process is determined from the formula

$$N_к = \frac{k \cdot q \cdot p_1}{(k-1)\,60 \cdot 75\, \underbrace{\eta_{мех}}_{\text{mekh}}} \left[\left(\frac{p_к}{p_1} \right)^{\frac{k-1}{k}} - 1 \right], \qquad [66]$$

where: N_k is the horsepower consumed by the compressor /152
when the fish-pumping unit is working only on intake;

p_k is the pressure developed by the compressor;

k is the index of the adiabatic process; (for air k = 1.4);

η mekh (mechanical) is the mechanical efficiency of the vacuum-air pump;

$$N_к = \frac{1{,}4 \cdot 6 \cdot 3{,}33}{(1{,}4-1)\,6 \cdot 75 \cdot 0{,}7} \left[\left(\frac{10{,}33}{3{,}33} \right)^{\frac{1{,}4-1}{1{,}4}} - 1 \right] = 8{,}6 \text{ л. с.} \text{—hp}$$

Where the mixture of water and fish must be raised to a height of 15 metres (including an intake height of 6 metres), the pressure in the receptacle will increase to p_2

$$p_2 = (15 - 6 + 10{,}33)\,10^4 = 19330\ \underset{\text{kg}}{\text{кг}}/\text{м}^2,\ \underset{\text{or}}{\text{или}}\ 19{,}33 \text{ м вод. ст.} \text{—metres of a column of water}$$

For reliable evacuation of the chambers and the creation of circulation in pipes 15 and 18 (see Fig. 48) air should be supplied in an amount exceeding by 10% the volume of the chambers arriving for unloading in the course of 1 minute. In this case, the volume of the compressed air fed into the sectors will amount to

$$q_1 = 1{,}1 \cdot 0{,}051 \cdot 7 \cdot 5{,}3 = 2{,}08 \text{ м}^3/\text{мин} \text{—m}^3/\text{min}$$

Where the pressure p_k = 3,330 kg/m^2 , the air will occupy a different volume, and the discharge of the vacuum-air pump when it is working on intake and lift will amount to

$$q_2 = 2{,}08\,\frac{19330}{3330} = 12{,}05\ м^3/мин.\text{—}m^3/min$$

The power consumed by the vacuum-air pump when the fish-pumping unit is working on intake and lift, will amount to

$$N'_к = \frac{1{,}4\cdot 12{,}05\cdot 3330}{(1{,}4-1)\,60\cdot 75\cdot 0{,}7}\left[\left(\frac{19{,}33}{3{,}33}\right)^{\frac{1{,}4-1}{1{,}4}}-1\right] = 28{,}2\ л.\,с.\text{—}hp$$

The power consumed by the electric motor driving the rotor will be very little, since the weight of the mixture in the chambers of the left-hand side of the rotor will assist the rotation.

The greatest power for rotating the rotor is required during starting. Since starting can be carried out even when there is already a complete vacuum in the upper part of the chamber, the pressure of the outside air, directed upwards, will act on the rotor. This force will equal

$$T = (p_a - p_1)\,F\cdot 1000, \qquad [67]$$

where F is the area of the projection of the rotor on a horizontal plane;

$p_a - p_1$ is the difference in the pressures of the outside air and within the rotor,

$$T = (10{,}33 - 3{,}33)\,0{,}8\cdot 0{,}8\cdot 1000 = 4550\ кг.\text{—}kg$$

This force will be counteracted by the weight /153 of the drum G = 500 kg. The moment of friction of the shaft of the rotor in the bearings will amount to

tr /friction/ $$M_{\text{тр}} = (T - G)\mu\frac{d_n}{2},\qquad [68]$$

where μ is the coefficient of friction for roller bearings, equal to 0.003;

d_n is the average diameter of a bearing, equal to 100 mm.

$$M_{\text{тр}} = (4550 - 500)\cdot 0{,}003\cdot\frac{0{,}1}{2} = 0{,}67\ \text{кгм.}$$ kilogram-metre

At the moment when the rotor begins to rotate, it may turn out that the first sector is completely filled with the mixture and tends to turn the rotor in the opposite direction. The maximum weight of the mixture in a section G_r = 51 kg. This force will be applied to the arm r = 0.2 m. Then the braking moment from the force G_r will be

$$M_T = 51\cdot 0{,}2 = 10{,}2\ \text{кгм}$$ kilogram-metres

The moment of rotation will be equal to the sum of the moments of friction and braking

tr /friction/ $$M = M_{\text{тр}} + M_T;$$ $$M = 0{,}67 + 10{,}2 = 10{,}87\ \text{кгм.}$$ kilogram-metres

Since no allowance was made in the calculations for an increase in the friction of the fins against the walls of the cylinder where scale or sand might have gotten into the clearances, nor was the resistance of the drum to starting taken into account, the moment of rotation should be at least doubled; then

$$M_1 = 2M;$$

$$M_1 = 2\cdot 10{,}87 = 21{,}74 \text{ кгм.} \quad \text{kilogram-metres}$$

With allowance for the efficiency of transmission, which is equal to 0.5, the power consumed on rotating the rotor will amount to

r [rotor]

$$N_p = \frac{M_1 n}{716{,}2\,\eta}; \qquad [69]$$

$$N_p = \frac{21{,}74\cdot 5{,}3}{716{,}2\cdot 0{,}5} \cong 0{,}35 \text{ л. с.,} \underset{\text{or}}{\text{или}}\ 0{,}42 \text{ квт.} \quad \text{hp} \quad \text{kw}$$

During the period when motion has been established, the rotation of the rotor will be opposed only by the moment of friction in the bearings and by the friction of the fins against the walls of the housing when scale or sand gets into the clearances. At 5.3 rpm, little power (0.1 to 0.2 hp) will be expended on this. Actually, during tests of the KRCh-1 the power consumed on rotating the gate rotor did not exceed 0.5 kw. /154

Allowing for the power consumed on rotating the rotor, we may assume that the total power consumption N where the fish are raised to a height of 15 m is equal (in round figures) to 29 hp.

When the KRCh-1 was tested at the Mokhovaya Fish Plant of the Avacha Fish Combine, the power consumption reached 30 to 32 hp where the mixture of water and fish was raised to a height of 13 metres. The increase in the actual power consumption of the KRCh-1 as against the rated power consumption may be explained by the low η_{mekh} of the vacuum-air pump that was used. In this case, the excessive inleakages of air were employed for useful work - the raising of the mixture of water and fish through a system of circulation pipes. Where the KRCh-1 worked only on intake, the extraneous inleakage of air lowered the efficiency of the unit.

We shall determine the speed of circulation of the water and mixture in the uptaking pipes where the delivery height H_k = 9 metres.

The quantity of air added to the mixture in the receptacle (see Fig. 48) comprises 10% of the volume of the chamber

$$q_в = 0{,}1 \cdot 51 = 5{,}1 \ дм^3 — dm^3$$

At atmospheric pressure this air will occupy the volume

$$v\ /air/ \quad q'_в = \frac{5{,}1 \cdot 19330}{10330} = 9{,}24 \ дм^3 — dm^3$$

The average volume of the air entering the delivery pipe in 1 second will be

$$q_{ср} = \frac{5,1 \div 9,24}{2} \cdot \frac{7 \cdot 5,3}{60} = 4,44 \text{ дм}^3/\text{сек} - \text{dm}^3/\text{sec}$$

sr [average]

Assuming conditionally that the velocity v of the movement of air bubbles is equal to the velocity v of the mixture of water and fish and is about 1.2 m/sec, we shall determine the quantity of mixture passing in 1 second through a pipe 250 mm in diameter,

$$Q_{см} = v \cdot t \cdot F,$$

sm [mixture]

where: F is the area of the cross section of the pipeline, in m^2;

v = 1.2 m/sec is the velocity of movement of the mixture in the pipeline;

t = 1 second.

$$Q_{см} = \frac{1.2 \cdot 1 \cdot 3,14 \cdot 0,25^2}{4} = 0,059 \text{ м}^3/\text{сек, или } 59 \text{ дм}^3/\text{сек}.$$

sm [mixture] m^3/sec or dm^3/sec

Since air will be included in this quantity of mixture, the average density of the mixture in the conduit 15 will be

$$\gamma_{см} = \frac{59 - 4,44}{59} = 0,925 \text{ кг}/\text{дм}^3 - \text{kg}/\text{dm}^3$$

sm [mixture]

The theoretical height of the column of mixture in the pipe 15 will be /255

$$h' = h\frac{1}{\gamma_{см}}, \qquad [70]$$

sm [mixture]

where: ρ_1 = 1 kg/dm^3 is the density of the water;

$$h' = 9\,\frac{1}{0{,}925} = 9{,}73\ \text{м}.$$

The difference in levels, in the pipes 15 and 16 will amount to

$$\Delta h = h' - h;\ \Delta h = 9{,}73 - 9{,}0 = 0{,}73\ \text{м}.$$

[Please ignore space below; text is continued on page 221.]

This difference in levels, with the exception of the geometric difference in the levels of the liquid in pipes 15 and 18, which is equal approximately to $\frac{0,25}{2} = 0,125$ м. is expended on overcoming local resistances in the system of the pipes 15 and 18 and the receptacle 7, i.e., it is an active pressure head, comprising.

$$\Delta h' = 0,73 - 0,125 \cong 0,6 \text{ м.}$$

We shall calculate the value of the local resistances at a speed v sr

The loss along the length of the stand pipe ($l \cong 12$ m) (see formula 18)

tr [pipe] $h_{w_{mp}} = \frac{0,02 \cdot 12 \cdot v_{cp}^2}{0,25 \cdot 2 \cdot 9,81} = \frac{0,96 \cdot v_{cp}^2}{19,62}.$ — sr [average]

The loss upon entry into the pipe (there are two entrances: one from the pan and another from the receptacle) (see formula 16)

vkh [entrance] $h_{w_{ex}} = 2 \cdot 0,50 \frac{v_{cp}^2}{2g} = 1 \frac{v_{cp}^2}{19,6}.$ — sr [average]

The loss in three elbows with a curvature (see formula 17)

$$\frac{D}{R} = 0,5;$$

kol [elbows] $h_{w_{кол}} = 3 \cdot 0,145 \frac{v_{cp}^2}{2g} = 0,435 \frac{v_{cp}^2}{19,6}$ — sr [average]

The loss in an elbow without a curvature (at the receptacle)

kol [elbow] $h'_{w_{кол}} = 1,13 \frac{v_{cp}^2}{2g} = 1,13 \frac{v_{cp}^2}{19,6}.$ — sr [average]

The sum of the losses in pressure head, expressed by the average speed, will [also] be expressed by the formula

$$\Sigma h_w = h_{w_{mp}} + h_{w_{ex}} + h_{w_{кол}} + h'_{w_{кол}};$$

$$\Sigma h_w = (0,96 + 1 + 0,435 + 1,13) \frac{v_{cp}^2}{19,6} = 3,525 \frac{v_{cp}^2}{19,6}.$$

The active pressure head is $\Delta h = 0{,}6$ м,

consequently, /156

$$0{,}6 > 3{,}525\frac{v_{cp}^2}{19{,}6}, \text{— sr /average/}$$

whence

$$\text{sr /average/ — } v_{cp} = \sqrt{\frac{0{,}6\cdot 19{,}6}{3{,}525}} = 1{,}80 \text{ м/сек. — m/sec}$$

Thus the active pressure head secures, in the system of the pipes 15 and 18, a circulation speed greater than the 1.2 m/sec that was originally proposed. Since, however, with the increase in the velocity the loss of air will also be greater, while the speed of the air bubbles will differ from that of the mixture, the velocity will actually be established within the range of 1.2 to 1.5 m/sec, which is quite acceptable. Such a speed will ensure the rapid discharge of the fish from the receptacle 7, to which it moves from a section of the rotor under the action of compressed air.

3. A Hydropneumatic Fish-Pumping Unit

The VNIRO Mechanization Laboratory (I.I. -eslin) has developed a hydropneumatic fish-pumping unit. The aim of the Laboratory has been to create a fish-pumping unit that would be capable of developing a high pressure head and that would be used for conveying fish to a considerable height or for considerable distances without causing them any mechanical injury.

This unit (see Fig. 51) consists of two airtight vertical cylindrical tanks mounted together, with conical lower bottoms and upper lids. To the lower bottom of each tank is connected a discharge pipe; both discharge pipes are brought together into a special box, in which there is a distributing device that alternately closes the outlet of one pipe and opens the outlet of the other pipe. From the distributing box there emerges one pipe, which represents the fish delivery conduit of the system.

Into the lower part of the cylindrical shell of each tank are led delivery pipes, which emerge from a distributing box installed in precisely the same way. An intake pipe into which a return valve has been built leads into the distributing box. An intake hose is lowered into a mixture of water and fish on board a fishing vessel; the hose draws out the mixture and directs it through the distributor to one of the tanks.

The distributing devices at the intakes and outlets of the tanks have been adjusted in such a way that when the intake pipe in one tank is open (while its outlet pipe is simultaneously closed), in the other tank the intake pipe is closed, and the outlet pipe is open.

Thus both tanks are alternately filled and emptied periodically, while the unit as a whole continually draws in and pumps a mixture of water and fish. /157

To each tank is attached an air pipe, through which compressed air enters the tank during the period when it is being emptied; during the filling period, the air is drawn from the tank through this same pipe.

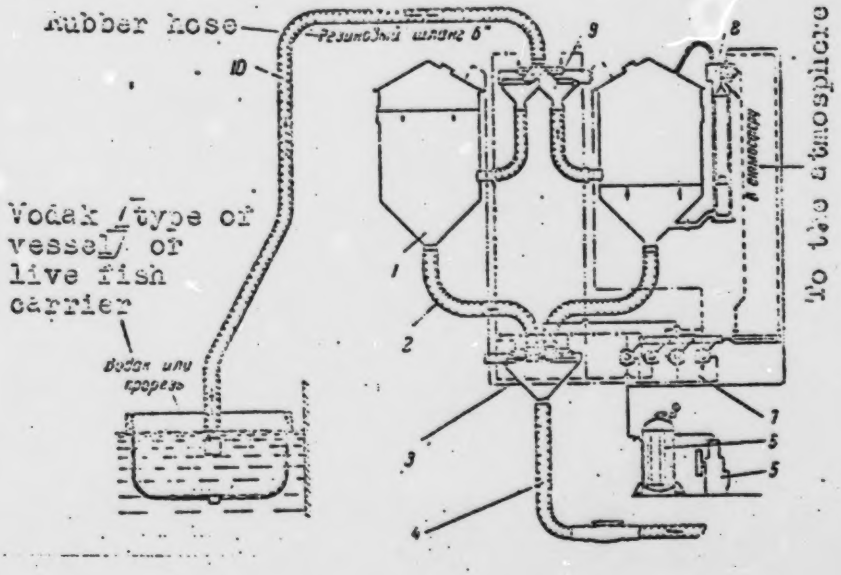

Rubber hose
Резиновый шланг 6"
10
9
8
To the atmosphere
В атмосферу
Vodak /type of vessel/ or live fish carrier
Водак или прорезь
1
2
3
4
5
5
7

Figure 51 - Diagram of a hydropneumatic fish-pumping unit:

1 - tank; 2 - discharge pipe; 3 - distributing box; 4 - fish delivery conduit; 5 - compressor; 6 - receiver; 7 - device for automatically changing the direction from which the mixture is being drawn in; 8 - float device for automatically controlling the level of the liquid in the tanks; 9 - distributor of mixture being drawn in; 10 - intake hose.

In the distributing box there is a plate that is connected to the piston rod of the pneumatic cylinder. The plate reciprocates within guides, alternately closing the openings now of one, now of the other pipe. In order that a fish that may by chance have gotten jammed in the passage will not be able to interfere with the tight closing of the pipe by the plate, the face edges of the latter are sharply pointed, causing it to cut through fish that have become jammed in its path.

A compressor and a vacuum pump are installed for feeding compressed air into the tanks and drawing air from them. Where the intake height is 1 metre and the delivery height is 20 metres, it is sufficient to use one compressor, operating on its intake side, as a vacuum pump.

The compressor feeds air into the receiver, whence it enters the system. For control of the pneumatic system the unit contains a distributing device in which are included four T-valves operated by levers connected by hinges to an oscillating gib. The gib is connected to the piston [158
rod of the pneumatic cylinder; the movement of the piston depends upon the float mechanism joined to the tank and acting through a four-way valve. The float mechanism follows the level of the liquid in the tank and automatically changes

over the compressor at the moment when the level of the liquid in the tank reaches the upper or lower limit.

When the contents of the tank are released into the discharge pipe, it [the tank] is not completely emptied, in order to prevent the escape of air from the tank into the outer system.

A hydropneumatic unit of the type that we have described was originally set up and tested in the spring of 1952 at the Azov Fish Combine, where it pumped pike-perch, bream and salted tiulka [Clupeonella d. delicatula].

In the autumn of 1952 a similar, but somewhat improved, unit of this type was set up at the Mysovskii Fish Plant of the Crimea State Fisheries Trust [Krymgosrybtrest] for pumping fresh anchovy.

The production area of the Mysovskii Fish Plant, with its buildings and installations for processing fish, is located on a plateau situated at a height of about 43 metres above sea level and terminating in a steep cliff leading down to the sea. Under the cliff is only a narrow strip of land that is scarcely sufficient for constructing a wharf and mounting machinery for unloading. Fish coming into the Mysovskii Fish Plant used to be be hoisted 43 metres, which was very difficult, since the sole means of transport was cable haulage. This haulage was inefficient; it did not secure the uninterrupted conveying of fish for processing, nor did it fit the system of hydraulic mechanization for unloading and conveying the fish.

Hence the installation of a hydropneumatic fish-pumping unit with a high pressure head at the Mysovskii Fish Plant was both highly advisable and necessary.

In tests at the Mysovskii Plant the hydropneumatic unit raised a mixture of water and fish to a height of 46 metres; its discharge of this mixture, where the latter's composition ranged from 1:2 to 1:3, was 60 m^3 per hour, i.e., its fish discharge was 15 to 20 tons per hour.

Since a hydropneumatic fish-pumping unit develops a high pressure head, it can be used for pumping fish for distances in excess 1 km (tentatively, 3.5 to 4 km horizontally).

There is now a hydropneumatic fish-pumping unit at the Mysovskii Fish Plant. It is possible to introduce it at other enterprises where the conditions under which fish are conveyed for processing require the installation of a fish-pumping unit developing a high pressure head.

Chapter VII

FISH CONDUITS

1. General Information

As a result of the use of fish pumps for unloading fish (this applies mainly to centrifugal fish pumps), it has become especially convenient to convey a pumped mixture of fish and water (or brine) through fish conduits, in this way uniting the processes of unloading and conveying fish into one complex, the fish conduits in this case representing a continuation of the fish-pumping units.

By their operating principles and installation, fish delivery conduits are divided into intake, delivery, and gravity conduits. The latter are frequently termed hydraulic pan conveyers.

Fish intake conduits are in most cases made from rubber hoses that are smooth inside and corrugated outside. Only in rare instances are they made from metal pipes. They are connected directly to the branch intake pipes of fish pumps. Fish delivery conduits, which are manufactured from various pipes or hoses, are connected to the branch delivery pipes of fish pumps. Thus they represent a continuation, as it were, of the fish pumps. Where delivery conduits are available, a mixture of fish and water can be conveyed both horizontally and vertically, following the relief of the terrain, which is extremely convenient. It has now become possible to convey a mixture of fish and water through fish delivery conduits for distances in excess of 1 km.

Hydraulic pan conveyers are made in the form of troughs of various shapes and designs. A mixture of fish and water is conveyed in them down a slope in the direction of movement. They are comparatively simple to install, and they permit considerable distances to be surmounted; not much additional power is consumed on them. Fish in hydraulic pan conveyers move in a stream of water; they are therefore preserved from injury and are at the same time thoroughly cleansed of dirt, slime and scale. Thus hydraulic pan conveyers represent a reliable and extremely hygienic means of transport.

2. Fish Intake and Delivery Conduits /160

The Installation of Fish Conduits

The fish intake conduits of fish-pumping units are designed for conveying a mixture of fish and water from the holds of transport ships, fishing gear, pickling tubs and other containers into the housing of the fish pump. Since fish intake conduits work under the action of a vacuum, they must be rigid enough not to contract, and flexible enough that they may be raised and lowered into the containers from which the fish is being pumped, as well as shifted within these container

In the vast majority of cases, therefore, reinforced rubber hoses are used that are corrugated outside and smooth inside. Rigid rubber hoses consist of two metal spirals placed between layers of rubber and fabric. The hoses have internal diameters of 100, 150, 200 and 250 mm and are either 4 or 8 metres long; at both ends the hoses have soft sleeves 125 to 150 mm long.

The spirals are manufactured from springy metal wire in diameters of 1.2 mm (the first spiral) and 3.5 to 4.5 mm (the second spiral).

The thicknesses of the layers of rubber are as follows:

upper layer	1.5 mm
middle layer	1.8 to 2 mm
inner layer	2 to 3 mm.

The two layers of fabric are each 1 mm thick. The full thickness of the wall of a rubber hose for various diameters ranges from 12 to 13.7 mm. The weight of a four-metre segment of hose is given in Table 13.

According to their technical specifications, rubber hoses should withstand an operating pressure of 1.5 atmospheres and a temperature ranging from + 50 to -30°. The sleeves of the hoses should be elastic and stretch by 5%. If a rubber hose must be bent, the radius of its curvature should be not less than four times its diameter.

In most cases, a return disc valve or a combined valve (a detailed description of both is given in Chapter VIII) is put on the end of a rubber intake hose. Where a fish intake conduit is very long, it is sometimes made of metal pipes, on the end of which is put a rubber hose of the design described above.

Steel (gas and seamless) and cast iron pipes are most frequently used as fish delivery conduits in the fishing industry. Ceramic and asbestos cement pipes are used on a smaller scale. Recently, glass and plywood pipes were tested on experimental units; the results, especially of the use of glass pipes, were quite favourable. In addition, canvas hoses have been widely used as fish delivery conduits, mainly in the Far East. Rubber hoses of the same type as on intake lines are used as fish delivery conduits comparatively /16 rarely owing to their considerable cost.

Delivery conduits can be laid directly on the ground, following its contours, or they can be mounted on light supporting structures both rectilinearly, which is the most desirable, and with bends and branch pipes. It is desirable to lay fish conduits with a slight elevation /sic/ in the direction of movement of the mixture of fish and water. This will prevent the formation of air pockets, which can in turn cause a bottleneck of fish to form.

The method of installing metal fish conduits is basically similar to that employed in laying water supply and sewage lines. There are, however, special requirements, which must be observed without fail.

Thus, all pipes, before they are laid, must be carefully examined, and protuberances and burrs inside them must be complete removed.

Pipe joints may be fitted on flanges and also welded, but care must be taken that no protuberances, which could injure the fish, form on the inner side of the pipe as a result of welding.

When the joints are fitted on flanges, special attention must be directed towards observing the coaxial alignment of the pipes, which will ensure the absence of projections in the path of the fish; such projections, as a rule, cause considerable injury to fish when the latter, mixed with water, pass through a conduit.

The radii of bends in curvatures and elbows should be as large as possible and in any case, must be not less than three to four times the diameter of the conduit itself.

Experience in work with delivery conduits when a mixture of fish and water of normal concentration is passing through them has shown that fittings in the form of branch pipes and T-pipes at angles of 30 and 45° may be used in such conduits. It i required only that they [the fittings] be carefully installed.

A long line of hoses is connected on branch pipes, which are usually manufactured of seamless pipes of suitable diameter narrowing to a cone; the edges of the branch pipes are machined for tighter fitting within the hoses, and the hoses are drawn together on the outside with clamps on bolts.

Such an arrangement of branch pipes ensures the absence of obstacles in the path of the fish and does not permit the formation between the connecting branch pipes and hoses of cracks that cause damage to the fish.

Among the drawbacks of fish delivery conduits manufactured from canvas hoses are their tendency to wear out quickly and the fact that they break on sharp bends. The cross section of a fish conduit narrows considerably in areas where breaks have occurred, and sharp corners appear which cause damage to fish that are being pumped. In order /162 to avoid this, smooth curved sections of a wooden trough are installed at the places where the fish conduit bends, and the canvas hose is laid in this trough. Otherwise, at sectors where bends occur, canvas hoses are replaced by rubber hoses.

In conduits made of canvas hoses, where there is a low pressure not exceeding 0.5 gauge atmosphere, individual segments of hoses may be joined without branch pipes by inserting one end of a hose into another for a length of 0.5 to 0.7 metres.

Fish delivery conduits made of canvas hoses are far lighter and cheaper than any other fish conduits; they are therefore widely used both for temporary facilities and when laying fish conduits over water on floats, for example, at fishing enterprises in Southern Sakhalin, in the Soviet Maritime Territory and in the Amur Basin.

Calculations for Fish Conduits

As is known from the theory of centrifugal pumps, the full pressure head or the full conveying height of such pumps is composed of the intake height and the delivery height, allowing for the height/amount/ of the hydraulic resistances in the intake and delivery conduits and in the housing of the pump itself.

Consequently, in order to make a correct calculation of the combined work of a centrifugal pump and conduits, we must know how to make calculations for the intake and delivery conduits, i.e., to determine the losses in them.

Research and observations carried out in recent years for determining the loss of pressure head in conduits when a mixture of fish and water passes through them have shown that when the mixture is moving at normal speeds (1.50 to 1.85 m/sec) the resistance to the movement of pure water and a mixture of fish and water in a ratio of 1:3 and higher is virtually the same. At lower and higher speeds of movement, an anomalous set of conditions has been disclosed that is similar to the conditions attending the movement through pipes of water with various impurities. This topic will be dealt with in greater detail below.

Owing to the fact that in a number of cases, and mainly under the normal conditions of the passage of a mixture of fish and water through pipes, the resistances of this mixture are close to those of pure water, we may utilize formulas that are used for calculating the resistances involved in the movement of pure water through pipes. In addition, below are given calculating formulas, obtained from research, for determining resistances in fish conduits upon the movement through them of a mixture of fish and water.

As has been noted in Chapter IV, the pressure head created by a fish pump can be established for corresponding model sizes and operating conditions either by determining it from characteristic curves on a graph, or on the basis of the readings of a vacuum gauge installed in front of the pump, at the end of the intake line, and a pressure gauge installed after the pump at the beginning of the delivery /163 conduit. When we have established the full pressure head developed by a fish pump, we determine the intake height; after this has been deducted from the amount of the full pressure head, we obtain the delivery height.

Determining the Intake Height

The correct designation of the intake height, as well as the proper arrangement and installation of the intake pipe, to a considerable extent promote the efficient and continuous operation of centrifugal fish pumps and the safety of the fish that are being transshipped.

In order to avoid inrushes of air into the intake pipe, and to secure the smooth entry of the mixture of fish and water into the spout of this pipe, it is necessary to lower the intake pipe below the surface of the liquid to a depth determined from the formula

$$h = a + b\frac{v^2}{2g}, \qquad [71]$$

where: h is the depth to which the pipe is lowered, in m;

v is the velocity of movement of the water in the intake pipe, in m/sec;

g is the acceleration of the force of gravity, equal to 9.81 m/sec^2;

a and b are coefficients equal respectively to 0.2 and 3.4.

The intake pipe should not be located too close to the bottom or the edge, since in this case the stream eddies, and there is an increase in the resistances as the mixture of fish and water enters the intake pipe.

Moreover, when the intake valve is lowered too close to the bottom of the ship, the valve usually adheres to the bottom and the fish pump stops operating.

For pure water, the distance between the bottom and the end of the intake pipe, as well as the distance from the edge, should not be less than 0.8 d, where d is the diameter of the intake pipe.

The fish intake conduit must be absolutely airtight and installed in such a way that the possibility of the formation of air pockets in it will be excluded.

The penetration of air into the intake line, even in small quantities, considergbly impairs the operation of centrifugal pumps, reducing their discharge and increasing the amount of rejects among the fish that are being transferred.

One of the most harmful consequences of an excessive intake height is cavitation. When cavitation occurs, some surfaces within the pump separate and collapse as a result of the formation on them of bubbles of steam and gas, which appear owing to a drop in the pressure of the pumped liquid below the pressure of the water vapour in certain parts of the pump. Externally, cavitation appears in pump ∠164 vibrations, noise, and a drop in efficiency.

The following areas are most frequently damaged in cavitation: the outer surfaces of the blades of the operating wheel at the intake; the ends of these blades; the area around the nut (here the stream upon entering the operating wheel changes its direction from axial to radial), and the housing of the volute at the point where the stream of liquid, coming off the blades of the operating wheel, is deflected.

In order to protect centrifugal fish pumps from cavitation, the correct intake height must be chosen and there must be a reduction in the speed with which the mixture of fish and water enters the operating wheel. For this purpose, the number of revolutions of the operating wheel must be reduced and the amount of hydraulic resistance decreased.

The greatest permissible geometric intake height for centrifugal pumps with one-way intake (among which are centrifugal pumps) can be determined from the formula

dop ∠permissible/

$$H_s^{\text{доп}} = \frac{p_a}{\gamma} - \frac{p_{\text{в.п}}}{\gamma} - \sum h_{\text{вс}} - \sigma H_{\text{н}}, \qquad [72]$$

vs ∠intake/

where: $\frac{p_a}{\gamma}$ is the atmospheric pressure in metres of a column of water, allowing for the height above sea level at which the pump is installed. For fish-pumping units at fishing industry enterprises this value can be assumed practically to be equal to 10 metres of a column of water;

$\frac{p_{w.p.}}{\gamma}$ is the pressure of the water vapour in metres of a column of water, in relation to the temperature of the water;

Water temperature in °C	Pressure of water vapour, in metres of a column of water
0	0,06
10	0,12
20	0,24
40	0,75

Σh_{wvs} is the sum of hydraulic resistances in the fish intake conduit (losses of pressure head), in metres of a column of water;

σ is the coefficient of cavitation, determined experimentally;

H_n is the full pressure head of the pump, in metres.

If no experimental data are available on the value [165 of the cavitation coefficient, the expression σH_{n} can be calculated from the following formula proposed by S.S. Rudnev:

$$\sigma H_{н} = \frac{n}{900}\sqrt[3]{Q^{2}n},$$

where: n is the number of revolutions of the operating wheel of the fish pump per minute;

Q is the full discharge of the fish pump in m^3/ sec.

Hydraulic resistances in both intake and delivery conduits, including fish conduits, are composed of losses of pressure head in straight sections and of local resistances, among which are losses of pressure head in intake valves, at turns, in abrupt and gradual widenings and narrowings in conduits, and in drains.

Losses of pressure head in straight sections of conduits depend upon the coefficient of roughness n of the inner surface of the pipes, which for metal pipes is usually taken as equal to 0.012 when they are in normal condition and use, and 0.013 under less favourable conditions.

In the first case, the loss in pressure head per running metre of conduit can be calculated from the formula

$$h_{w_{тр}} = 0{,}0014822\,\frac{Q^{2}}{d^{5.333}}\ м/пог.\ м, \qquad [73]$$

tr [conduit] metres/running metre

while in the second case

$$h_{w_{тр}} = 0{,}00176\,\frac{Q^{2}}{d^{5.333}}\ м/пог.\ м, \qquad [74]$$

tr [conduit] metres per running metre

where: $\underline{Q}$ is the full discharge of the fish pump, in m^3/ sec;
$\underline{d}$ is the diameter of the fish conduit in metres.

In order to simplify calculations, tables have been prepared in which losses of pressure head have been determined for water in conduits of various diameters at different flow rates and at different coefficients of roughness of the pipes.

In Table 9 are given the values of the moduli $\frac{0.0014622}{d^{5.332}}$ where $\underline{K} = 0.012$ and $\frac{0.00175}{d^{5.332}}$ where $\underline{K} = 0.013$ for a number of diameters of fish conduits used in fish-pumping units.

When we have multiplied the obtained value of $h_{w_{tr}}$ by the length of the fish intake conduit, we obtain the full value of the loss of pressure head in a straight section $\sum h_{w_{tr}}$.

Losses of pressure head in rubber hoses, depending upon the latter's condition, are 10 to 15% higher than in metal conduits, for which the above formulas have been given.

Table 9

The Value of Moduli in Making Calculations For Fish Conduits

Diameter of pipe, in mm	$\frac{0.0014822}{d^{5.232}}$	$\frac{0,00176}{d^{5,3.2}}$
100	319,20	387,00
125	97,15	117,70
150	35,72	44,40
200	7,92	9,55
250	2,41	2,90
300	0,91	1,09
350	0,40	0,48

For asbestos-cement and concrete pipes, losses of pressure head are equal to those for metal pipes, while /166 for canvas hoses losses of pressure head should be increased 1.5 to 2 times in comparison with losses in metal pipes.

Losses of pressure head from local resistances can be determined from Weissbach's formula (see formula /17/)

mest /local/ $$h_{w_{\text{мест}}} = \zeta \frac{v^2}{2g},$$

where: ζ is the coefficient of local resistance;

v is the velocity of the stream behind /or beyond/ local resistance in m/sec;

g is the acceleration of the force of gravity, equal to 9.81 m/sec ^{2}.

The values of the coefficients of certain local resistances for round pipes of various diameters used in fish-pumping units are given below.

1. The disc intake valve when it is fully opened (see Fig. 52). The coefficient of local resistance is composed of:

a) losses from smooth entry into the pipe — $\zeta_{\text{вх}} = 0{,}20$;

b) losses in the valve — $\zeta_{\text{кл}} = 0{,}10$.

The full coefficient — $\zeta_{\text{дкл}} = 0{,}30$.

vkh /entry/
kl /valve/
dkl /disc valve/

2. Bends in the pipes:

a) smooth

b) sharp.

A diagram of a smooth bend in a pipe is shown in Fig. 53.

The coefficient of local resistance ζ — pl. pov /smooth bend/ where there is a smooth bend $\alpha = 90°$ depends upon the value of the ratio $\frac{R}{d}$:

$\frac{R}{d}$	1,0;	1,5;	2,0;	3,0;	4,0;	5,0;	6,0;	7,0;	8,0;	9,0;	10,0;	15,0
$\zeta_{\text{пл.пов}}$	1,10;	0,85;	0,70;	0,66;	0,63;	0,60;	0,60;	0,60;	0,60;	0,60;	0,60;	0,60

pl. pov

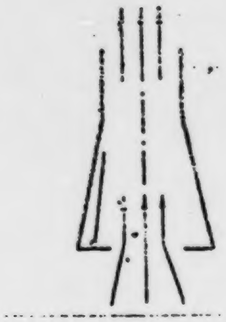


Figure 52 - Diagram of a disc valve.

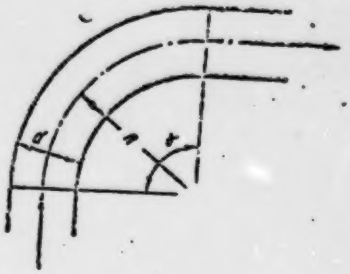


Figure 53 - Diagram of a smooth bend in a pipe.

With different values of the angle α the coefficient of local resistance $\zeta_{w_{\text{pl. pov}}}$ ∠167 can be calculated from the formula

$$\zeta'_{w_{\text{пл. пов}}} = f(\alpha)\zeta_{w_{\text{пл. пов}}}.$$

pl. pov

Below are given values of the quantity $f(\alpha)$ depending upon the amount of the central angle α of the bend in the pipe

α°	20	30	40	50	60	70	80	90	100	120	140
$f(\alpha)$	0,40	0,55	0,65	0,75	0,83	0,88	0,95	1,00	1,05	1,13	1,20

$\alpha^\circ = 60;\ 180$ $f(\alpha)$ 1,27; 1,33

A diagram for a sharp bend in a pipe is shown in Fig.54.

The coefficient of resistance $\zeta_{w_{\text{rez. pov}}}$ ∠sharp ben depends upon the angle of the bend α:

α°	30	40	50	60	70	80	90
$\zeta_{w_{\text{рез. пов}}}$	0,20	0,30	0,40	0,55	0,70	0,90	1,00

rez. pov

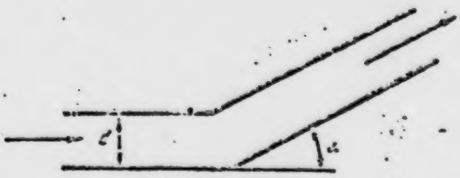


Figure 54 - Diagram of sharp bend in pipe.

3. Abrupt widening of pipe (see Fig. 55). /168

The coefficient of resistance where there is an abrupt widening

ζ = vn. rassh [abrupt widening] depends upon the ratio of the ar

of the cross sections of the pipe $\frac{F}{f}$:

vn. rasah

$\frac{F}{f}$	10	9	8	7	6	5	4	3	2	1
$\zeta_{вн.расш}$	81	64	49	36	25	16	9	4	1	0

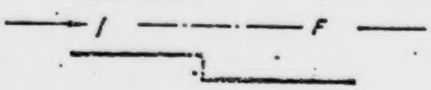


Figure 55 - Diagram of sudden widening of pipe.

4. Smooth widening of pipe (see Fig. 56).

The coefficient of resistance ζ = pl. rassh [smooth widening] depends upon the amount of the angle α:

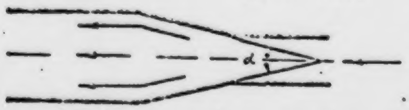


Figure 56 - Diagram of smooth widening of a pipe.

pl. rassh

α°	7	10	15	20	25	30	35	40	45	50
$\zeta_{пл.расш}$	0,22	0,46	0,54	0,60	0,67	0,73	0,79	0,84	0,88	0,91
α°	55	60	65	70	75	80				
$\zeta_{пл.расш}$	0,91	0,91	0,91	0,91	0,91	0,91				

5. Abrupt narrowing of a pipe (see Fig. 57).

The coefficient of resistance ζ_{w} vn. suzh [abrupt narrowing] depends upon the ratio of the areas of cross sections of the pipe $\frac{f}{F}$:

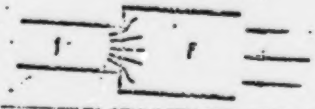


Figure 57 - Diagram of abrupt narrowing of a pipe.

$\frac{f}{F}$ 0,00; 0,10; 0,20; 0,40; 0,60; 0,80; 1,00

vn. suzh —— $\zeta_{w\,\text{вн.суж}}$ 0,5 ; 0,45; 0,40; 0,30; 0,20; 0,10; 0,00;

6. Smooth narrowing of pipe (see Fig. 58). /169

The coefficient of resistance ζ_{w} pl. suzh [smooth narrowing] depends upon the amount of the angle α :

α° 7 ; 10 ; 15 ; 20 ; 25 ; 30 ; 35 ; 40; 45; 50;
α° 55; 60 ; 65 ; 70 ; 75 ; 80 .

pl. suzh —— $\zeta_{\text{пл.суж}}$ 0,16; 0,16; 0,18; 0,20; 0,22; 0,24; 0,26; 0,28; 0,30; 0,31;
—— $\zeta_{\text{пл.суж}}$ 0,31; 0,32; 0,33; 0,34; 0,34; 0,35

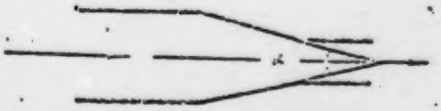


Figure 58 - Diagram of smooth narrowing of pipe.

7. Outlets and branch pipes.

The values of the coefficients of resistance $\zeta\ \underline{w}_{\underline{otv}}$ [outlets $\overset{\text{and}}{/}$branch pipes] with various outlets and branch pipes are shown in Fig. 59.

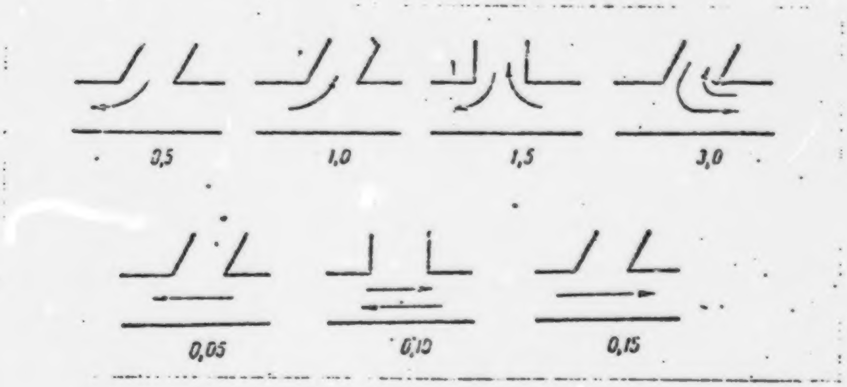


Figure 59 - Diagram of outlets and branch pipes

When we have substituted in Weissbach's formula the corresponding values of the coefficients of local resistance, and have added up the losses in pressure head both from resistance in the straight section and from local resistances, we shall obtain the full height of the resistances from losses [17] of pressure head in the fish intake conduit.

$$\sum h_{w_{vs\,[intake]}} = \sum h_{w_{tr\,[pipe]}} + \sum h_{w_{mest\,[local]}}$$

The obtained value of $\sum h_{w_{vs}}$ should be inserted in formula [72], which determines the greatest permissible geometric intake height of a centrifugal fish pump.

Making Calculations for a Fish

Delivery Conduit

The full intake height developed by a fish pump can be used either for raising a mixture of fish and water to a given height or for conveying this mixture through a fish conduit laid horizontally or with a certain elevation.

Losses of pressure head in fish delivery conduits are calculated according to the formulas from which losses of pressure head in fish intake conduits (see preceding paragraph) are calculated.

Then the geometric delivery height for a given model size of fish pump and for its corresponding operating conditions will be obtained as the difference of the full delivery height and the sum of all losses. In addition, from the full delivery height there must be subtracted the value 0.11 to 0.16 metres - the reserve of pressure head for pouring out the mixture.

All of the formulas cited relate to the passage of pure water through metal conduits.

As a result of the study of the conditions of movement through pipelines of various heterogeneous streams, such as mixtures of water and peat (hydropeat*), earth, paper pulp, and various industrial waste products (pieces of hide, etc.), the following general conclusions have been made.

1. The water content in a heterogeneous stream is one of the main factors affecting resistance during the passage of this stream through pipes. The more water in the stream, the closer the resistance comes to that for pure water.

2. As the water content in a heterogeneous stream decreases, the appearance of abnormal conditions is observed. Abnormal conditions consist in the fact that at low speeds (as a rule, about 1 metre per second and slower) losses in conduits are greater than during the passage of pure water.

---

* Translator's note: A direct rendition of the Russian gidrotorf.

These losses quickly increase as the speed of the stream drops, and at speeds of about 0.1 m/sec for some masses they increase three to five times in comparison with losses for water. On the other hand, when there is an increase in speeds (usually above 1.5 to 2 m/sec), where heterogeneous streams are passing through pipes, the losses of pressure head decrease in comparison with losses for pure water, and at speeds approaching 3 m/sec they become 25 to 30% less than for water.

3. When water moves through delivery conduits, the resistance is to a certain degree proportional to the speed, /17 but in the movement of heterogeneous streams this proportionality disappears.

4. The presence of abnormal conditions during the passage of heterogeneous streams through delivery conduits can be explained by the fact that the eddies produced in boundary layers as a result of the friction of the stream against the walls of the pipes (such eddies become larger where the pipes are very rough) affect hydraulic resistances in various ways when pure water and a mixture pass through a pipeline.

In the first instance, the eddies, entering the centre of the current, as the speed of the stream increases usually develop further and bring the stream in the pipe to a whirlpool condition, thereby increasing the resistance of the stream to movement.

In a heterogeneous stream the eddies that have been produced in boundary layers enter the centre of the current and usually attenuate rapidly, owing to which resistance to movement does hot increase. Moreover, the thicker the heterogeneous stream, i.e., the less water in it, the faster attenuation takes place.

In order to demonstrate the peculiarities of the conditions under which a mixture of fish and water passes through pipelines, VNIRO (I.I. Teslin) has conducted a number of investigations, the results of which permit the following conclusions.

The irregular conditions observed during the movement through conduits of various heterogeneous streams, are also observed when a mixture of fish and water moves through conduits.

Irregular conditions differ somewhat for various species of fish and for mixtures of different concentration, but on the average at speeds of movement of less than 1 to 1.5 m/sec the resistance to movement of a mixture of fish and water is 1.10 to 1.35 times greater than for pure water. Within the speed range of 1.5 to 1.85 m/sec this resistance is approximately equal to the resistance for pure water, and at high speeds (3 m/sec) it amounts to approximately 90% of the resistance to movement of pure water.

The losses of pressure head from local resistances upon the passage of a mixture of fish and water at speeds of 0.30 to 2.55 m/sec are virtually equal to those for pure water. At high speeds they rapidly diminish, and at a speed of 3.60 m/sec they are approximately half those for water.

The viscosity of pure water at the same temperature is virtually equal to the viscosity of a mixture of fish and water.

The resistances to movement of a mixture of fish and water have a certain slight tendency to increase in relation to an increase in the degree of concentration of fish in the mixture.

In Fig. 60 are shown curves, obtained from research, of the relation of the coefficients of friction λ L-72
to the speed of movement $\underline{w}$ during the movement in a pipe of pure water and a mixture of fish and water. It may be seen from an examination of the curves $\lambda - \underline{w}$ for water and for a mixture of fish and water that at speeds of about 1.70 to 1.85 m/sec the curves intersect and, consequently, the resistance to movement of heterogeneous streams is equal.

At lower speeds, the resistance to movement of a mixture of fish and water increases in comparison to the resistance to movement of pure water, and at higher speeds it decreases.

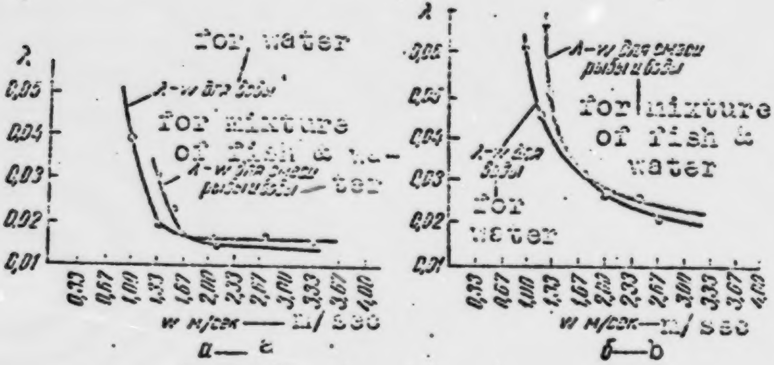


Figure 60 - The relation of the coefficient of friction to speed during movement:

a - of pure water and a mixture of anchovy and water in a pipe 100 mm in diameter; b - of pure water and a mixture of bream and water in a pipe 250 mm in diameter.

I.I. Teslin has proposed the following formula for calculating the loss of pressure head during the movement of a mixture of fish and water through conduits ranging in diameter from 100 to 250 mm:

$$-\underset{\text{sm = mixture}}{\frac{dp_{см}}{dl}} = \frac{dp}{dl}\left(a + bc + k e^{\frac{-\lambda c}{m}}\right)^*,$$

where: a, b, k and $\frac{1}{m}$ are coefficients;

c is the concentration of fish in the mixture, determined from the formula $c = \frac{Q_r + Q_v}{Q_v}$;

Q_r and Q_v are the quantities of fish and water respectively (in equal measures) passing through a fish conduit during equal intervals of time;

e is the base of Napier's logarithm, equal to 2.718.

N.F. Chernigin (TINRO) has concluded that in the /17 movement of a mixture of pink salmon and water in a proportion of 1:10 through fish conduits 250 mm in diameter the resistance of the mixture to movement is virtually equal to the resistance occurring during the movement of pure water.

The optimum speeds of movement of a mixture of fish and water through fish conduits range from 1.2 to 1.7 m/sec. At these speeds the fish during their movement on the one hand do not lag behind the water,

---

* For more detail see Trudy VNIRO [VNIRO Publications] XXII, State Scientific and Technical Publishing House for the Food Industry [Pishchepromizdat].

and on the other hand are not injured in movement, i.e., these speeds are close to those at which equality of resistances is observed in the movement of mixtures of fish and water and pure water. Taking all of this into account, we may, with sufficient accuracy for practical purposes, make calculations for fish conduits at normal speeds and concentrations of fish in a mixture according to the formulas for pure water which were given in the preceding paragraph.

3. Hydraulic Trough Conveyers

The conveying of fish in a stream of water through open troughs of different designs - so-called hydraulic trough conveyers - installed with a certain slope in the direction of movement, have long been in use at several enterprises of the fishing industry.

Hydraulic trough conveyers are used either jointly with centrifugal fish pumps (in this case the mixture of fish and water is fed into the trough directly by a fish pump) or together with other unloading facilities (for example, cranes, water-jet fish pumps, elevators etc). In the latter case, the fish are usually fed into the trough by an inclined scraper conveyer or an elevator, and the water, by a separate pump.

According to their operating principle, hydraulic trough conveyers should have a slope in the direction of movement of the mixture of fish and water; therefore the initial part of the trough must be raised as high as possible above ground level, particularly in the case of long hydraulic conveyers.

The troughs of hydraulic conveyers used at enterprises of the fishing industry differ greatly both in the design and shape of their cross sections and the slopes at which they are set.

At Kamchatka fishing enterprises troughs are made of galvanized iron and have semispherical bottoms. A diagram of such a trough is given in Fig. 61. The trough is supported by a wooden framework resting either on posts or on a wooden trestle. The slopes at which the troughs are set usually amount to about 0.02. The fish are conveyed for considerable distances of up to 0.5 km; hence they must be lifted at intervals with the aid of inclined scraper conveyers.

Salmon are conveyed in a stream of water through these troughs from the wharf to the receiving bins of canneries.

The ratios of fish and water vary within a wide range /17 (from 1:1 to 1:10 and more).

At fishing enterprises on the Azov, Black, and Caspian Seas the troughs have a rectangular cross section and are made of boards smoothly planed within. The seams between the boards are caulked and filled with pitch.

The troughs of the hydraulic conveyers used at the Crimea State Fisheries Trust for anchovy have a cross section of 350 x 500 mm and a slope of 0.005. An overall view of a hydraulic pan conveyer at the Crimea State Fisheries Trust is given in Fig. 62.

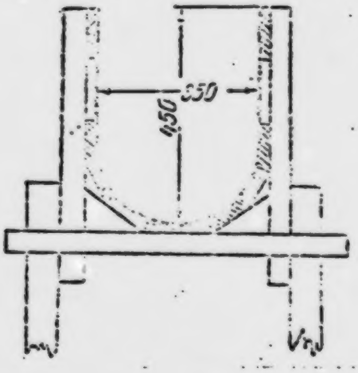


Figure 61 - Cross section of the trough of a hydraulic conveyer used at Kamchatka canneries.

At fish plants on the western shore of the Caspian Sea hydrualic conveyers whose troughs have a cross section of

400 x 600 mm and a slope of 0.005 to 0.02 are used for herring. The ratios of fish and water also vary within wide limits (from 1:1 to 1:10).

The above examples of the installation of hydraulic conveyers in the fishing industry show that there is no uniformity in the selection of shapes of cross section, designs, or slopes of troughs.

On the basis of experimental data, a conveying speed of about 1 m/sec and no higher than 2 m/sec may be recommended for a mixture of fish and water passing through open troughs.

The slope for a trough lies within the limits of 0.005 to 0.02, i.e., the drop in the height of the trough in relation to a horizontal plane can comprise from 0.5 to 2 cm per running metre of trough. A slope of 0.005 is used for small fish (sprat, anchovy, tiulka, etc), and a slope of 0.02 for large fish (pike-perch, chum, pink salmon, etc.). It is desirable that the ratio of fish and water in the trough be within the range of 1:3 to 1:8; where the ratio is less than 1:3, the fish can form layers in the trough, while a ratio greater than 1:8 is disadvantageous, since too large a trough cross section is required.

The fundamental formula for making calculations for the trough of a hydraulic pan conveyer is the equation of the continuity of the stream and the constancy of the flow rate

$$Q = Fv = \text{const},$$

where: Q is the volume of the mixture of the fish and water in m^3/sec;

F is the cross section of the stream in m^2;

v is the velocity of the stream in m/sec.

The volume Q of the mixture of fish and water can be determined from the formula /175

$$Q = 0{,}001\,(q_{р} \div q_{в}), \qquad [75]$$

where: 0.001 is the coefficient allowing for the volumetric weights of fish and water, which are assumed to be identical and equal to 1,000 kg per cubic metre;

q_r is the quantity of fish, in kilograms, passing through the trough in one second;

q_v is the same for water.

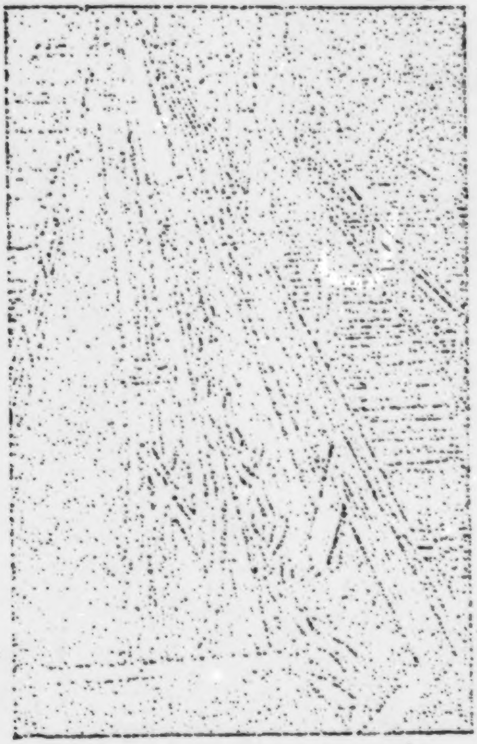


Figure 62 - Hydraulic pan conveyer of the Crimea State Fisheries Trust.

The cross section of the stream of a mixture of fish and water in the trough of a hydraulic conveyer is determined from the formula

$$F = \frac{0{,}001\,(q_р + q_в)}{v}. \qquad [76]$$

The speed of the stream of a mixture of fish and water can be determined from Chezy's formula ⌊ 176

$$v = C\sqrt{Ri}, \qquad [77]$$

where: C is a coefficient related to a number of factors associated both with the physical properties of the stream and with the constructional peculiarities of the trough;

R is the hydraulic radius of the stream;

i is the slope of the trough.

The following formula, recommended by Academician N.N. Pavlovskii for pure water, may be used for determining the coefficient C for a mixture of fish and water in normal concentrations:

$$C = \frac{1}{n} R^y, \qquad [78]$$

where: n is the coefficient of roughness of the inner surfaces of the trough;

y is an index whose average value can be assumed to be equal to 1/6;

R and i are the same as in formula [77].

The coefficient of roughness $\underline{n}$ can be taken as follows for various kinds of troughs:

troughs with concrete plastering...........	0,010
" of planed boards..................	0,011
" of galvanized iron	0,012
" of unplaned boards	0,013
" of canvas	0,015

The hydraulic radius $\underline{R}$ is the ratio of the area of the cross section of the stream in the trough $\underline{F_m}^2$ to the moistened perimeter of the trough in metres. Thus the hydraulic radius is directly proportional to the area of the cross section of the stream and inversely proportional to the moistened perimeter. Hence there is more advantage in selecting the moistened trough perimeter which will be the least where the cross section of the stream is of the same area.

Semicircular troughs satisfy this condition. In the lower corners of wooden and concrete troughs it is advisable to install longitudinal triangular cleats, which reinforce the structure of the trough and make its rectangular shape approximately semicircular (see Fig. 63). The greater the hydraulic radius R and the slope i, the greater the capacity of the hydraulic conveyer.

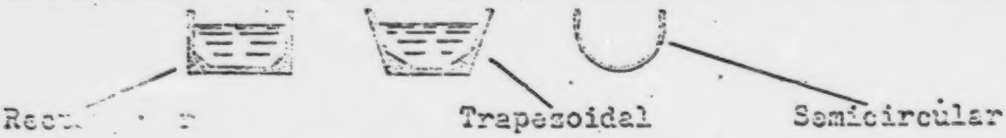


Figure 63 - Shapes of cross sections of hydraulic conveyer troughs.

In Table 10 are given some practical data characterising the operation of a hydraulic pan [trough] conveyer. [177

Table 10

Date on Hydraulic Pan [Trough] Coveyers

	Cross section of trough in metres				
	0.4 x 0.4	0.3 x 0.3	0.2 x 0.2	Slope	Speed of stream in m/sec
	Capacity in cubic metres per hour				
Performance data	393 544 670 678	330 465 563 653	101 142 174 200	0,005 0,010 0,015 0,02	0,9–1,3 1,3–1,9 1,6–2,3 1,8–2,3
	Nominal dimensions of trough				

[see next page]

Area of cross section of trough, in m^2	0,16	0,03	0,04
Area of cross section [of stream] in m^2	0,12	0,07	0,03
Moistened perimeter, in m.	1,0	0,75	0,5
Hydraulic radius, in m.	0,12	0,09	0,06
Coefficient C	35.4	50,5	55,0

The troughs of a hydraulic conveyer can be installed not only in a straight line, but also with bends in a plane. In some cases a bend in a trough may even be made at a right angle. For this purpose, the trough that is proceeding in the original direction is cut off, and under it is placed a trough going in the other direction. As a result, the stream of fish and water runs off into the lower trough and moves in the new direction. In addition, at the place where the stream is redirected a shield is installed which keeps the stream from splashing out. The distance to which the stream drops must be made minimum.

If fish must be unloaded from the trough of the hydraulic conveyer at several points, hatches (see Fig. 34,a), which are tightly closed with lids fastened on hinges, are installed in the bottom of the trough at the places where unloading must be carried out. The lids open upwards, thereby blocking the path of the stream of the fish-and-water mixture. In addition, a gate fastened on hinge to the wall of the trough (see Fig. 64, b) may be used. The gate can be swung so that it faces the stream. A guide strip /178 with a slot, to which the gate can be fastened in the required position with a wing nut is usually installed at the top of the trough.

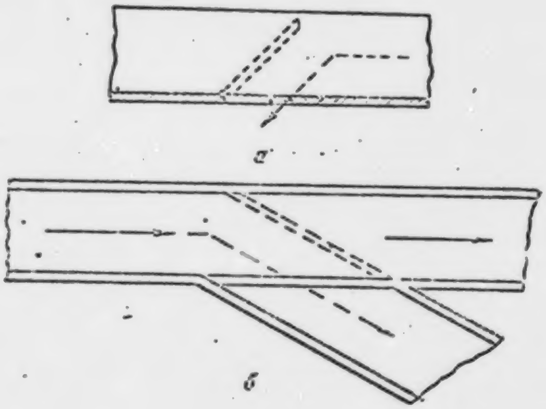


Figure 64 - Diagram of a trough for unloading fish at several places:

a - using a hatch; b - using a hinged gate.

The troughs of hydraulic conveyers are installed on posts or on trestles which reach a considerable height. At large fish plants where there are many shops to which fish are delivered in troughs, the latter are installed in the form of a branched system that extends through the entire fish plant and has a total length of 2,000 to 2,500 running metres. At the same time, the height of the trestle reaches 12 to 14 metres.

In this way, the network of hydraulic conveyers does not interfere with other intraplant transport located under the trestle.

CHAPTER VIII

AUXILIARY DEVICES FOR FISH-PUMPING UNITS /179

1. Priming Devices and Return Valves

A peculiarity of centrifugal pumps, including centrifugal fish pumps, is the necessity for priming the intake conduit and the pump housing with water before starting.

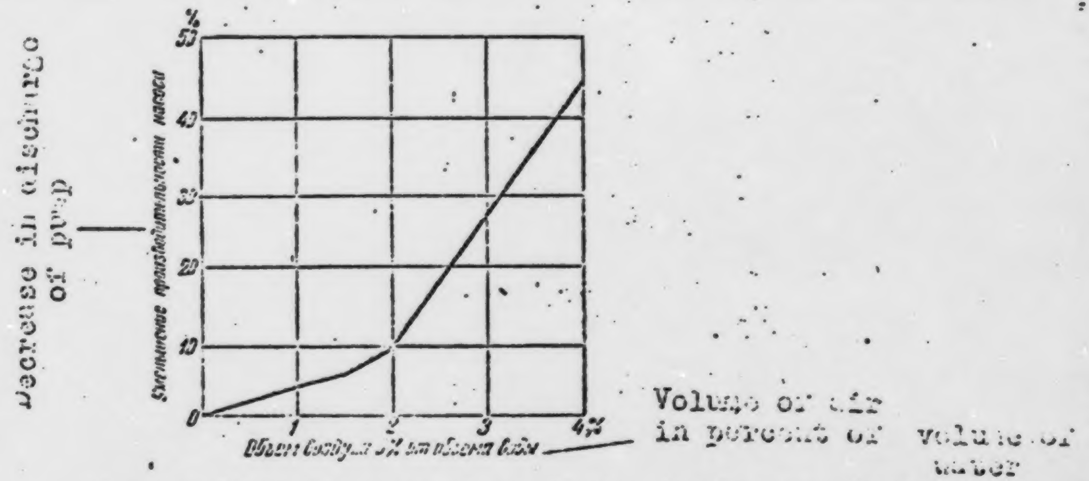


Figure 65 - The relation of the discharge of fish pumps to the volume of air entering them.

When air enters the inner cavity of a centrifugal fish pump even in small amounts, the pump's operation is disrupted, and when the quantity of air increases, the productive work of the pump ceases completely. Research has shown that as long as the quantity of air that has entered does not exceed 1.5% of the volume of water, the relation between the reduction in the discharge of the fish pump and the quantity of air that has entered it is approximately directly proportional (see Fig. 65). Upon the further entry of air, the discharge of the fish pump drops sharply. For example, when air enters in the amount of 4% of the volume of [160 water, the discharge of the fish pump drops by more than 40%. When an amount of air representing about 10% [of the volume of the water] enters, both intake and delivery stop.

Devices that prime pumps before the latter are started may be divided into the following groups:

1) devices with a return valve (snore piece) on the intake conduit;
2) those with combined valves;
3) those using automatic intake pumps and return valves on the delivery conduit;
4) those with other automatic priming attachments.

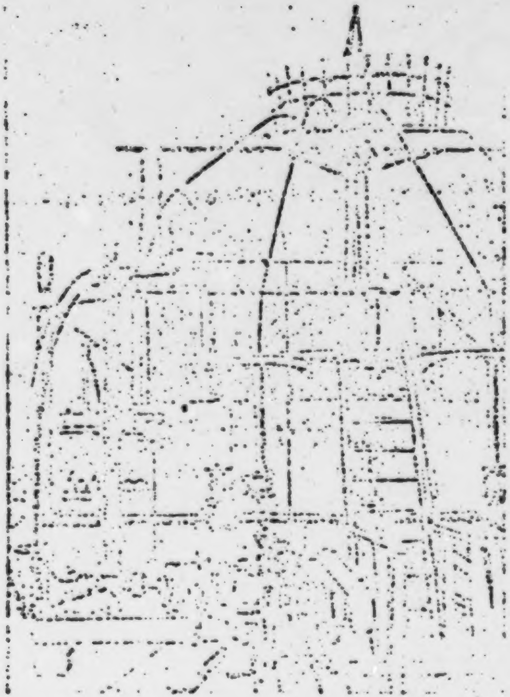


Figure 66 - Installation of a fish pump with a priming tank.

The operating principle of a unit with a return valve on the intake conduit is as follows. Before it is started, the pump is primed with water through a valve or an air cock located in the upper part of the pump housing. In order that the water being poured into the pump will not run out through the intake conduit, on the end of the latter is installed a return valve (a snore piece) whose disc is pressed by the water to the casing of the valve and thereby prevents the water from running out.

The fish pump can be primed either directly from a water-supply system or from a priming tank installed on the wharf at a certain elevation in order to secure a pressure head.

A priming device of this kind (see Fig. 66) is the simplest, but it has a number of negative features, mainly:

1) the necessity of installing a return valve on the intake conduit. This valve must be lowered into the mass of fish contained in fishing gear or in a ship's hold (from which the fish /18 must be pumped), and it must be moved about in this mass. The return valve, therefore, can be a cause of injury to the fish that are being pumped;

2) in the event that air rushes in through the intake valve, the pump must be stopped and primed again, which is undesirable both from the operational viewpoint and, chiefly, because of the possibility of additional injury to the fish;

3) since after the pump has shut down, the intake hose and the pump volute remain filled with fish and water, it is difficult to maneuver the heavy hose; therefore, special cranes must be installed.

The return valve (see Fig. 67) has a welded metal casing consisting ———————————————————————

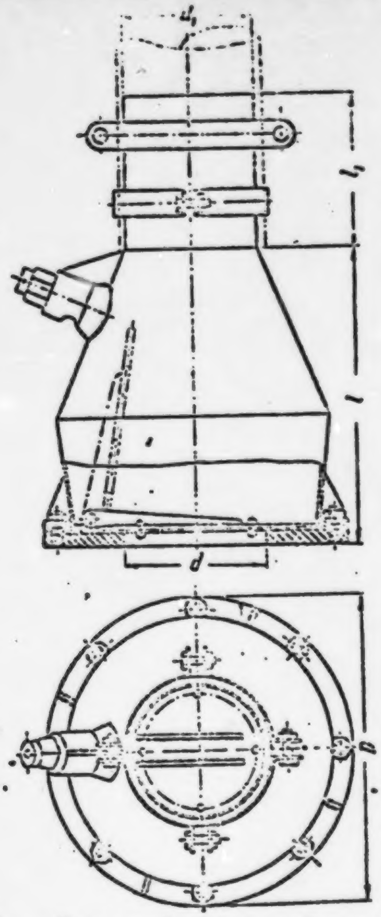


Figure 67 - General view of return valve (shore piece).

---

of two reciprocal cones and changing, in its upper part, into a cylindrical branch pipe entering the intake hose of the fish pump and fastened to it with metal clamps. In the lower part of the casing of the return valve there is fastened (on a hinge) a round metal disc, to which is attached, on the outer side, a leather or rubber ring that secures the water-proofness of the valve. The diameter of the intake opening, which is situated in the lower part of the return valve casing, is somewhat greater than the diameter of the intake hose.

The return valve casing is of a shape that permits the disc fastened on a hinge to assume, when it is opened, a position which does not obstruct the free, straight-line movement of fish when the latter are being drawn in. In order to release water from the valve and the intake hose, in the side wall of the upper cone of the return valve casing is installed a discharge faucet /182 equipped with a leather gasket and fastened with a nut.

In Table 11 are given the main data on return valves manufactured by plants of the fishing industry.

Table 11

Main Sizes and Weight of Return Valves

(see Fig. 67)

Type of return valve for		Basic dimensions, in mm					Approximate weight in kg
		D	d	d_1	l	l_1	
RB	РБ-100	295	120	100	258	160	14,8
	РБ-150	365	170	150	343	180	21,8
	РБ-200	420	220	200	385	200	35,5
	РБ-250	560	275	250	484	330	94,0 без рас-труба — without bell mouth

In Table 12 are given the total weights of hoses (with return valves) filled with water for various model sizes of centrifugal fish pumps.

Table 12

Weight of Intake Hoses with Return Valves

Model size of fish pump	Weight of empty four-metre rubber hose, in kg	Weight of water in four-metre segment of rubber hose, in kg	Weight of return valve, in kg	Full weight in kg
РБ-100	16,0	31,4	14,8	62,2
РБ-150	24,0	70,7	21,8	116,5
РБ-200	32,0	125,6	35,5	193,1
РБ-250	40,0	196,3	94,0	330,3

In some cases, because of local conditions two or more four-metre segments of intake hose must be installed; hence the full weight of the entire installation increases even more.

Several designs of combined intake valves for fish pumps have been proposed almost simultaneously in order to improve conditions for the formation of a working mixture and to secure the automatic starting of the fish pump if the work is interrupted by the entry of air into the intake hose.

The essence of these proposals is that the main volume of /183 water that is to form the working mixture, is fed not into the cargo hold of the ship containing the fish, but rather into the intake hose and the intake valve that is on it, or towards the very mouth of the valve.

A combined valve designed by Borshchenko (see Fig.68) consists of a conical bell mouth into which is inserted a segment of pipe terminating in a valve (a gate valve) that is shut off manually with a system of levers. Water from an auxiliary pump is fed to the valve through an elbow pipe. Within the pipe there is a hinged gate. An outlet that is closed with a valve leads away from the pipe supplying the water. A hose is put on the end of this outlet. The water for flooding the fish in the hold can be supplied directly to the mouth of the valve.

Before the fish pump is started, the valve (the slide valve) is shut off, and the auxiliary pump forces water into the valve, the intake hose and the fish pump. Simultaneously, part of the water is fed through the outlet to the mouth of the valve, forming a thick mixture. The mixture, as it is being drawn into the hose of the fish pump, is diluted inside it [the pump] with water fed by the auxiliary pump; a working mixture of normal composition is formed in the process.

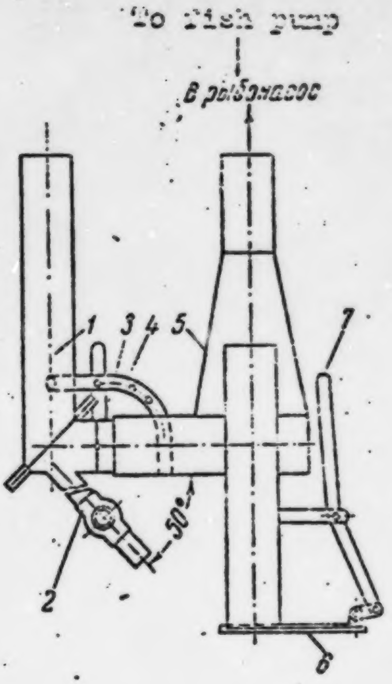


Figure 68 - Combined valve designed by Borshchenko:

1 - pipe for supply of water from auxiliary pump; 2 - outlet for flooding fish in hold; 3 - regulator of water supply to intake pipe; 4 - sector for securing lever to controlling gate; 5 - casing of combined valve; 6 - slide valve; 7 - lever for controlling slide valve.

Air, when it enters the intake hose and the fish pump, is forced out by the thrust of the stream of working mixture, which is under the pressure developed by the auxiliary pump. This prevents the stoppage of the fish pump when air gets into it and permits its operation to be automatically renewed.

Among the disadvantages of Borshchenko's valve design are the manual control of the slide valve and the gate on the water delivery pipe, and the considerable weight of the valve.

A combined valve designed by Kozyrev (see Fig. 69) differs from Borshchenko's valve in that its mixing bell mouth is set directly on the branch intake pipe of the fish pump, while thin /18 rubber hoses terminating in nozzles and feeding part of the water from the auxiliary pump directly to the mass of fish, lead to the mouth of the hose, at the end of which is a normal fish-pump intake valve.

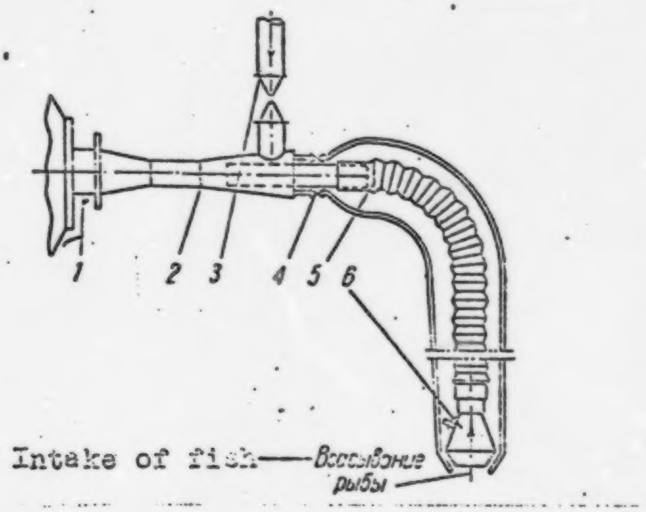


Figure 69 - Combined valve designed by Kozyrev:

1 - Branch intake pipe of RB fish pump; 2 - mixing chamber 3 - pipe for supplying water from auxiliary pump; 4 - outlets with valves for supplying water to fish in ship's hold; 5 - intake hose; 6 - normal intake valve.

The lack of manual control of the valve and the transfer of the mixing chamber to the fish pump lighten the intake hose and make this unit more convenient than the preceding [Borshchenko's] apparatus. In Kozyrev's unit, however, the mixture of fish and water must pass through the intake hose without being diluted, which, when the mixture is thick, increases the extent of injury to the fish. The working mixture must therefore be thinned as much as possible before it reaches the valve.

A combined valve designed by Burkal'tsev (see Fig.70) consists of two bell mouths, of which one (the larger) is inserted into the intake hose of the fish pump, and the other (the smaller) is introduced into the larger bell mouth and forms in it a tapering nozzle, through which the working mixture is drawn into the valve. Water from the auxiliary pump is fed through the hose to a branch pipe welded into the large bell mouth and enters it [presumably the branch pipe]. Part of the water is fed through a separate hose into an annular pipe with openings (a diffuser) welded to the flange of the bell mouth and, flowing out through the openings, drenches the fish at the mouth of the valve. To the flange of the bell mouth is fastened a bottom with a hinged intake valve (a plate). The mouth of the valve is enclosed by a ring welded on legs to this bottom; owing to the [resultant] enclosure, the valve does not adhere to the bottom of a hold from which fish are being pumped. [185

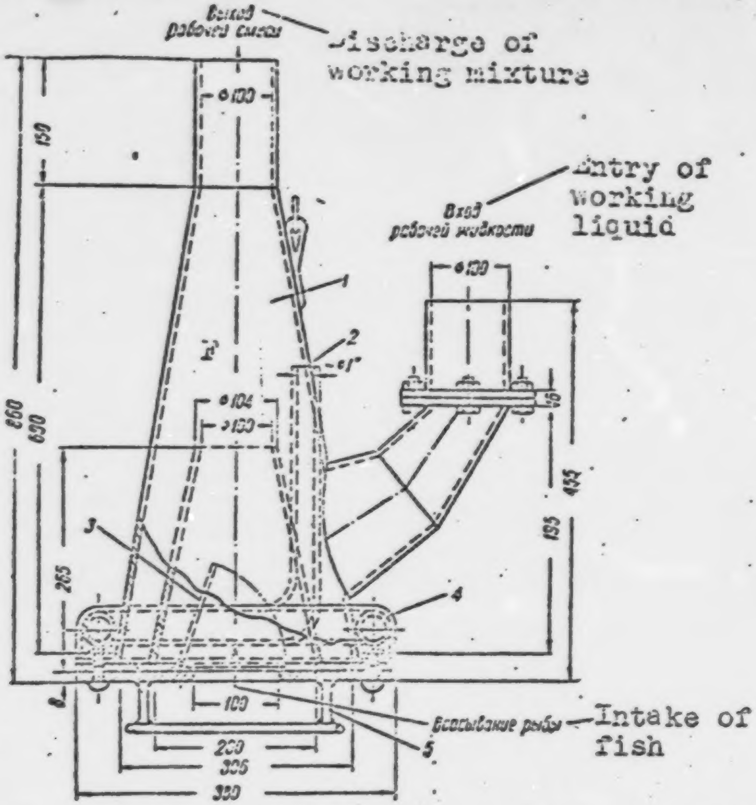

Выход рабочей смеси
Discharge of working mixture
ø100
150
Entry of working liquid
Вход рабочей жидкости
ø100
1
2
ø1"
F
ø104
ø100
860
690
455
195
265
3
4
10
8
100
Всасывание рыбы
Intake of fish
5
200
306
330

Figure 70 - Combined valve designed by Burkal'tsev:
1 - valve casing (mixing chamber); 2 - pipe for feeding water to diffuser; 3 - valve plate; 4 - diffuser for delivering water to fish; 5 - guard grating at mouth of valve

---

The valve designed by Burkal'tsev has no manual control; the fish in the valve are diluted with water near the mouth. The valve, however, is extremely awkward and heavy, which hinders operations with the intake hose of a fish pump equipped with it.

/136

A combined valve designed by Zadorozhnyi (see Fig. 71) differs from the preceding valves in that the fish are diluted with water not within the valve itself, but near its mouth. The cone-shaped stream of liquid for mixing and drawing in the fish, however, is here restricted because of the use of a jacket, into which water is fed from the auxiliary pump.

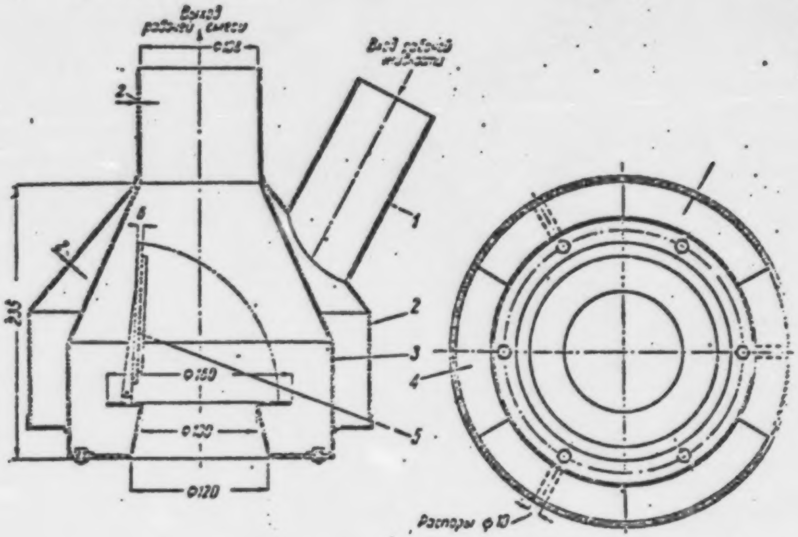


Figure 71 - Combined valve designed by Zadorozhnyi:

1 - pipe for supplying water from auxiliary pump; 2 - jacket; 3 - valve casing; 4 - openings in bottom of jacket for supplying water; 5 - valve plate.

The jacket is welded onto an ordinary intake valve, which differs from a standard valve in that into it is welded a guide cone, on which is located the gate (plate) of the valve. In the bottom of the jacket are three openings through which water is fed from the jacket in directed streams towards the fish, forming a working mixture with the latter in a restricted zone.

The valve designed by Zadorozhnyi is lighter than all of the preceding valves, but it cannot automatically restore the operation of the fish pump when air enters the latter.

Thus of the four designs of combined valves, not one is without various considerable drawbacks; moreover, they are all heavier and more cumbersome than return valves (shore pieces).

It is more difficult to maneuver with them, since to the increase in the weight of the valve itself is added the weight of an additional hose that is also filled with water (see Table 13).

From a comparison of the full weights (given in Tables 12 and 13) of units for corresponding model sizes of fish pumps, it may be seen that where combined valves are used, these weights more than double.

Table 13

Full Weight of an Intake Device with a Combined Valve

Model size of fish pump	Weight of two four-metre segments of hose, in kg	Weight of water in two segments in kg	Weight of combined valve, in kg	Full weight, in kg
РБ-100	32.0	62,8	35,3	130,1
РБ-200	64.0	251.2	83.7	398.9

At the Osipenko Fish Plant Engineer B.T. Burkal'tsev [1] assembled an RB-100 fish pump unit with an ejector device (see Fig.72). The ejector device designed by Burkal'tsev was connected to the branch intake pipe of a fish pump, which permitted the elimination of the following main shortcomings of combined valves: the necessity for maneuvering with a heavy hose, and the difficulty of regulating the delivery of water to such valves. At the same time, this arrangement secured the continuous operation of a centrifugal fish pump.

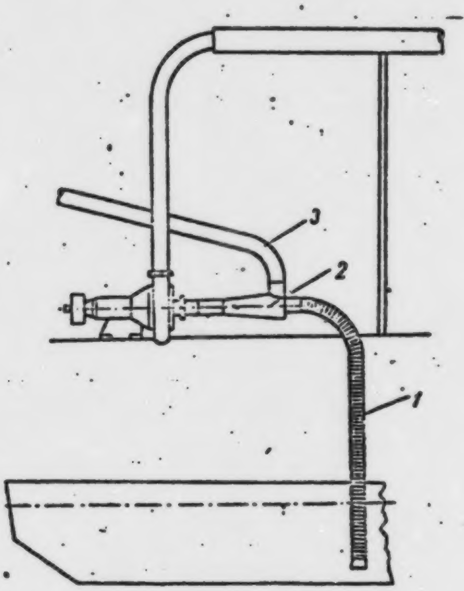


Figure 72 - RB-100 fish pump with ejector device designed by Burkal'tsev:

1 - intake hose; 2 - ejector on intake hose of fish pump;
3 - pipe for supplying water to ejector.

The ejector device and the volute of the fish pump were filled up with the same pump that delivered water to the ship for flooding, after which the fish pump was ready for work.

When air entered the fish pump, the intake was automatically restored with the aid of the ejector, which secured the continuous operation of the RB-100 fish pump, considerably simplified the servicing of fish-pumping units, and excluded the necessity for installing any kind of valve at the end of the intake hose.

Favourable results were obtained during tests at the Osipenko fish plant of an RB-100 fish pump unit with the ejector device designed by Burkal'tsev; moreover, the fish that were pumped were completely protected from mechanical injury. /138

Among the third group of devices for priming centrifugal pumps, including fish pumps, are units using automatic intake pumps and return valves on the delivery conduit.

The action of automatic-intake water-circulating vacuum pumps* is based on the following principle.

---

* Translator's note. See Translator's note, p 172.

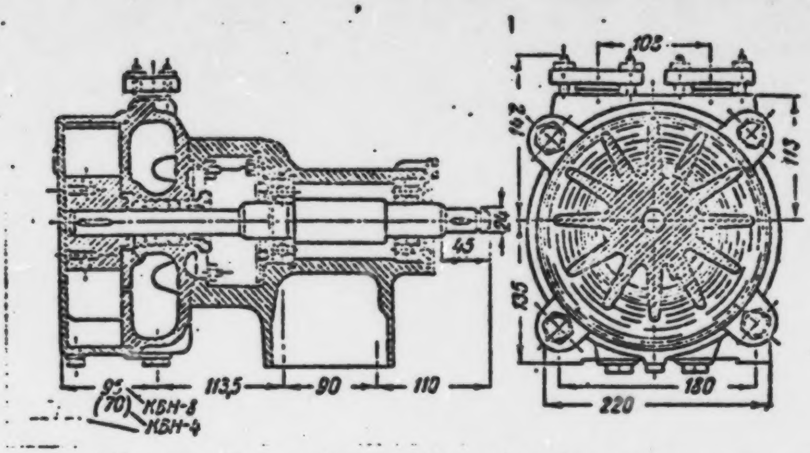


Figure 73 - Water-circulating vacuum pump

Through the cylindrical housing of this pump passes a shaft on which is set eccentrically a star-shaped wheel whose blades in their upper part come up against the inner side of the pump housing, while a clearance remains below. On both sides of the pump shaft bushing are crescent-shaped grooves - one for intake and the other for delivery.

Into the pump housing is fed water, which, when the pump shaft and the star-shaped wheel turn, forms a moving ring that under the action of centrifugal force presses against the inner surface of the housing.

When the ring of water withdraws from the boss of the shaft, a vacuum is formed that causes air to be drawn in through the large crescent-shaped groove. Compression occurs upon further rotation, and air is expelled through the small crescent-shaped groove.

The intake opening (the large crescent-shaped groove) is connected to the volute of the centrifugal pump, while the delivery opening (the small crescent-shaped groove) connects with the outside air. When the water ring rotates within the housing of the vacuum pump, air from the volute of the centrifugal pump and the intake hose is drawn off through the intake opening and is expelled through the delivery opening. This process takes place continually while the water ring of the vacuum pump is rotating; owing to this, air is rapidly drawn /139
off both before the fish pump is started and during inrushes of air when the pump is operating.

Such a method of priming ensures that centrifugal pumps work steadily and that the fish that are pumped are preserved from injury.

Cantilever vacuum pumps of types KVN and RMK[1][*] (see Fig.73) may be recommended as water-circulating pumps for the above purpose. The pump can be connected with an engine by a belt transmission or a clutch. The main data for vacuum pumps are given in Table 14.

---

[1] KVN pumps are now manufactured by special contract with the factory.

[*] Translator's note. See Translator's note, p 172.

Table 14

Data on Water-Circulating Vacuum Pumps*

Type of pump	Discharge in cubic metres per minute	Vacuum in metres of a column of water	Rpm	Consumption of cooling water, in litres per hour	Power required for electric motor, in kw	Weight of pump, in kg
KVN — КВН-4	0,4	7—8	1450	250—300	1,5	38
КВН-8	0,8	7—8	1450	250—300	2,2	42
RMK — РМК-1	1,5	9,0	1450	10	4,5	93
РМК-2	4,2	9,2	1450	20	10,0	109
РМК-3	11,5	9,7	950	60	29,0	475
РМК-4	27.0	9,6	720	108	70,0	1028

In order that a common motor may be used with [both the vacuum pump and] the fish pump, on the shaft of the latter is provided a place to install an additional pulley for a belt drive for the vacuum pump.

The operating characteristics of vacuum pumps of the KVN type at 1,430 rpm are given in Fig. 74.

A small manual piston pump of the Garda or BKF type has been successfully used on small fish-pumping units for withdrawing the air from the housing and the hose of a centrifugal fish pump and for priming them with water before starting.

---

*. Translator's note. See Translator's note, p 172 .

Where water-circulating vacuum pumps or piston pumps are used, it is possible not to install a return valve on the intake hose. In this case, an ordinary spout with a small bell mouth is installed at the end of the intake hose, and when fish are pumped from fishing gear, a framework is arranged which prevents the del'* of the seine from being drawn into the hose. A diagram of such a spout with a framework is shown in Fig. 75. /19

When air is drawn out of the intake hose and the volute of the fish pump, however, they must be insulated from the outer atmosphere, which will rush into the space when the pressure is lowered.

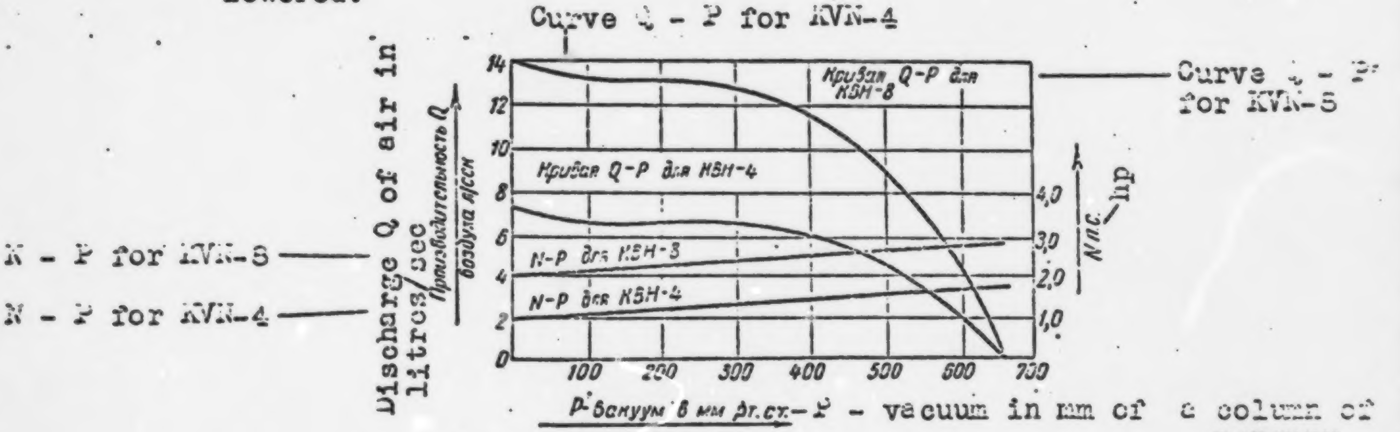


Figure 74 - Operating characteristics of a water-circulating vacuum pump.

---

* Translator's note. No suitable equivalent is available for this term, which may designate possibly the meshed fabric or a fitting of the net.

A return valve must therefore be installed on the branch delivery pipe, immediately behind the housing of the fish pump.

One of the designs of such a return valve developed by VNIRO consists of two shaped branch pipes, between which a disc, inclined at an angle of 45°, is fastened on hinges. This ensures the utilization of the weight of the disc when it is pressed to the projection of the branch pipe irrespective of whether the return valve is installed vertically or horizontally (see Fig. 76).

In the upper branch pipe of the valve are two small inspection windows made of organic glass or celluloid for seeing to the correct operation of the disc and the concentration of fish in the mixture that is being pumped.

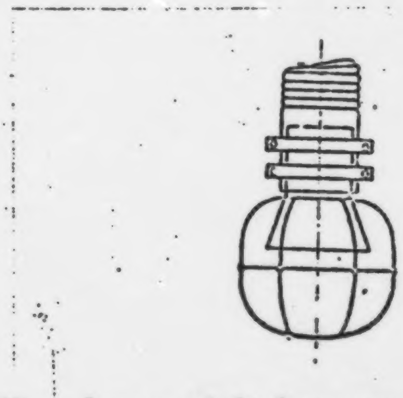


Figure 75 - Spout with framework for preventing the del'[x] of the seine from being drawn in.

Translator's note. See Translator's note, p 345.

A rod for controlling the disc is passed through the cover of the upper branch pipe of the valve and through a stuffing box. The rod is fastened to the disc on a hinge.

The weight of the valve is 21 kg. Its operation is based on the fact that when air is drawn from the intake hose and the volute of the fish pump, the valve disc, under the effect of the atmospheric pressure, presses against the projection of the branch pipe, cutting off the access of the outer air through the fish delivery conduit. When the fish pump begins to operate, the mixture of fish and water by its pressure raises the disc, which secures free passage of the mixture. /191

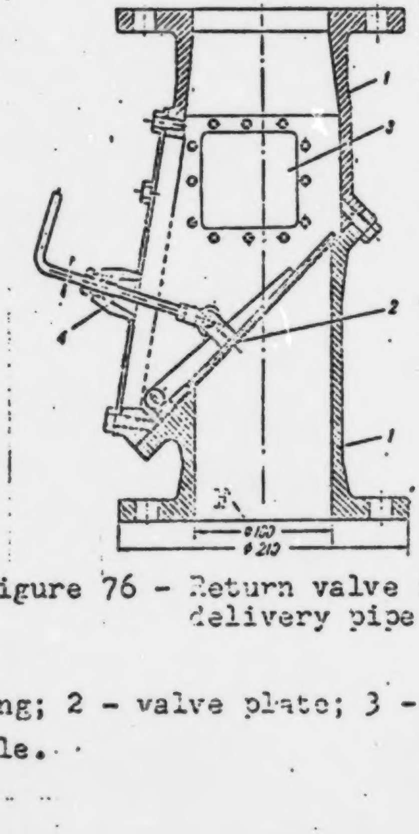


Figure 76 - Return valve installed on the branch delivery pipe of a fish pump:

1 - casing; 2 - valve plate; 3 - inspection window; 4 - handle.

Where delivery conduits are short, it is advisable to use a gate valve at the end of the delivery conduit instead of return valves installed on the branch delivery pipe of the fish pump. This device /the gate valve at the end of the delivery conduit7 consists of a spout put on the end of the delivery conduit. To the spout is fastened, on a hinge, a metal disc with a leather or rubber ring. The disc has a counterweight that presses it to the spout when the fish pump is not working or when air is being withdrawn from the fish pump and the latter is being primed. The disc opens under the pressure of mixture of fish and water, and the fish can pass through freely. The gate valve (see Fig. 77) is simpler to manufacture and operate than a return valve installed on the branch delivery pipe of a fish pump.

Worthy of attention in this respect is the small vacuum tank proposed by Engineer V. B. Kokhanovich, which was tested under industrial conditions at the Novoust'inskii Fish Plant of the Chief Directorate of the Fishing Industry of the Amur Valley /Glavamurryboprom7. The vacuum pump for the RB-150 (see Fig. 78) consists of a metal tank (at the suggestion of

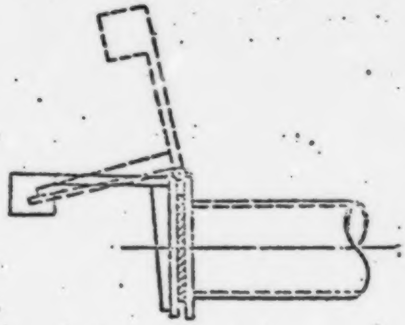


Figure 77 - Gate Valve

---

the author, a 250-litre barrel) having branch pipes above and below with flanges for connection to the intake hose and the intake opening in the volute of the fish pump. The latter connection is made with a segment of elastic rubberized hose. The vacuum tank should be placed above the centre of the intake ∠19. opening of the fish pump.

In the centre of the vacuum tank is welded a metal cone in accordance with the dimensions indicated in Fig. 78. The cone serves to eject air which may be located in the upper part of the tank. Before work begins, the vacuum tank is completely filled with water through a tap. Since the vacuum tank is located above the volute, the volute casing and the intake hose are filled up simultaneously to the level of the tap. After the tap has been turned off, the unit is ready for operation.

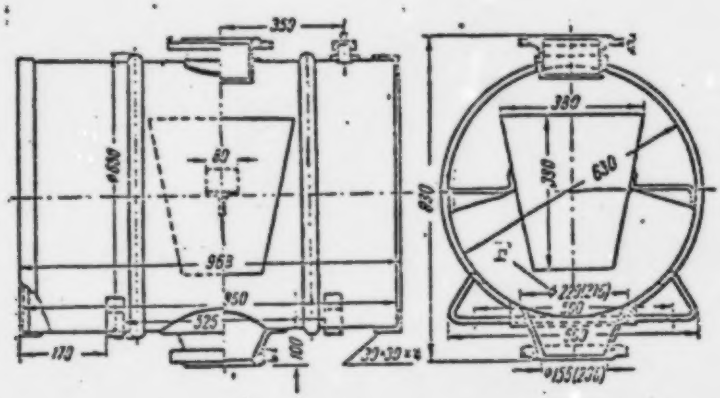


Figure 78 - Vacuum tank for RB-150.

When it is started, the fish pump will draw in a certain portion of the water from the tank; in place of this water, at first air, and then a mixture of water and fish, will be drawn from the hose. The air will remain in the upper part of the tank, while the mixture of water and fish will pass in a stream through the ejection cone and will enter the directing cone of the flange.

Further on, the mixture of water and fish will go through the intake pipe into the rotor and the volute of the fish pump in the usual order.

As practice has shown, the air that has accumulated in the upper part of the vacuum tank is gradually ejected (caught) by the stream of water-and-fish mixture through the cone and is expelled in small portions by the fish pump without noticeable disturbance of the normal process.

When air occasionally rushes into the intake hose, it is also retained in the vacuum tank, and the operation of the fish pump is not disrupted. After some time, this air is expelled from the vacuum tank in small portions through the cone. When the fish pump stops, the vacuum tank remains filled with water, owing to which the RB, after it has stopped, can be started again without priming.

The vacuum tank, which does not particularly complicate the fish pump unit, makes it possible to work without a shore piece and with automatic resumption of the work of the fish pump when air rushes into the intake hose. Moreover, when the vacuum tank is installed, the priming of the RB is simplified. /193 A disadvantage is the necessity for the operator to estimate precisely the moment at which the fish pump is to be stopped in order to retain water in the vacuum tank for the purpose of automatically priming the volute during subsequent starting. The complexity of such an estimate is obvious where the operator has no devices of any kind for controlling the moment at which the air in the hose approaches the flange upon the termination of unloading.

It is to be expected that where the design of a vacuum tank has been properly developed for all model sizes of fish pumps, the use of such a tank will improve the operation of stationary RBU units with a short intake hose and a reverse valve on the fish delivery conduit. Where the fish-pump intake hose is long, the vacuum tank is evidently not practicable because of its large dimensions.

2. Auxiliary Pumps

Auxiliary pumps at fish plants serve to prime fish pumps and to flood the holds of transport vessels carrying fish, as well as to pump brines in pickling sheds. Below are given the most generally used designs of pumps serving auxiliary purposes.

Pumps of the NF make belong to the sewage type, and in their working principle are very similar to centrifugal fish pumps of make RB. Pumps of the NF make are manufactured in several model sizes, of which the 2.5NF and the 4NF are most frequently used as auxiliary units (the figures indicate the diameter of the branch pipe in inches, while the letters expand to "fecal pump" [In Russian, nasos fekal'nyi].

The 2.5NF pump (see Fig. 79) is recommended for use as a mobile pump during the canting of fish in tubs. The 4NF pump works well at fixed brine stations. In order to avoid foaming of the brines, the speed of the pump wheel must not be increased above 1,450 rpm.

The basic technical data and dimensions of the 2.5NF and 4NF pumps are given in Tables 15, 16 and 17; the characteristics of these pumps are given in Fig. 80.

Table 15

Basic Technical Data of NF Pumps (see Fig. 80)

Make of pump	Delivery		Full pressure head H, in metres	Rpm	Power		Efficiency, in %	Permissible vacuometric intake height, in metres	Diameter of wheel, in mm
	in m³ per hour	in litres per sec.			Shaft, in hp	Engine, in kw			
2,5НФ . .	36	10	9,8	1450	3,1	2,2	43	5,5	195
2,5НФ . .	72	20	6,5	1450	4,4	5,2	39	5,5	195
4НФ . .	108	30	26	1450	20	20	52	6,0	300
4НФ .	180	50	23	1450	27	21	56	5,0	200
4НФ .	72	20	11	975	6,0	5,0	49	6,0	300
4НФ	101	28	10	975	6,7	5,0	56	6,0	300

Table 16

Basic Dimensions of NF Pumps in mm (see Fig. 79, a)

Pump make	A	B	V	G	D	E	Zh	Z	I	K	L	Weight in kg
2.5NF ...	[illegible]	760	255	170	390	360	200	125	300	270	22	160
4NF	283	765	300	175	390	360	200	190	300	270	22	240

Table 17

Branch Pipes (see Fig. 79, a)

Pump make	Branch intake pipe (dimensions in mm)				Number of bolts	Branch delivery pipe (dimensions in mm)				Number of bolts	Diamet of suction valve (recommended in mm
	D	o	a	d under bolt		D_1	o_1	a_1	d_1 under bolt		
NF 2,5HΦ	76	150	190	18	4	65	130	160	15	4	155
NF 4HΦ	100	170	210	18	4	100	170	210	18	4	200

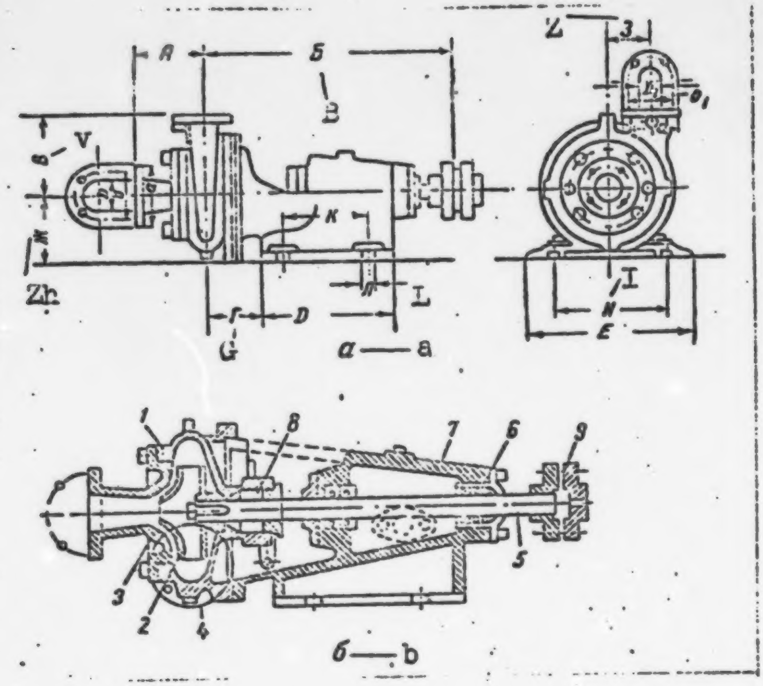


Figure 79 - Pump of type 2.5NF;
a-overall view; b-cross section

1 - pump housing; 2 - wheel; 3 - branch intake pipe;
4 - branch delivery pipe; 5 - shaft; 6 - shaft bearings;
7 - frame housing; 8 - stuffing box; 9 - clutch

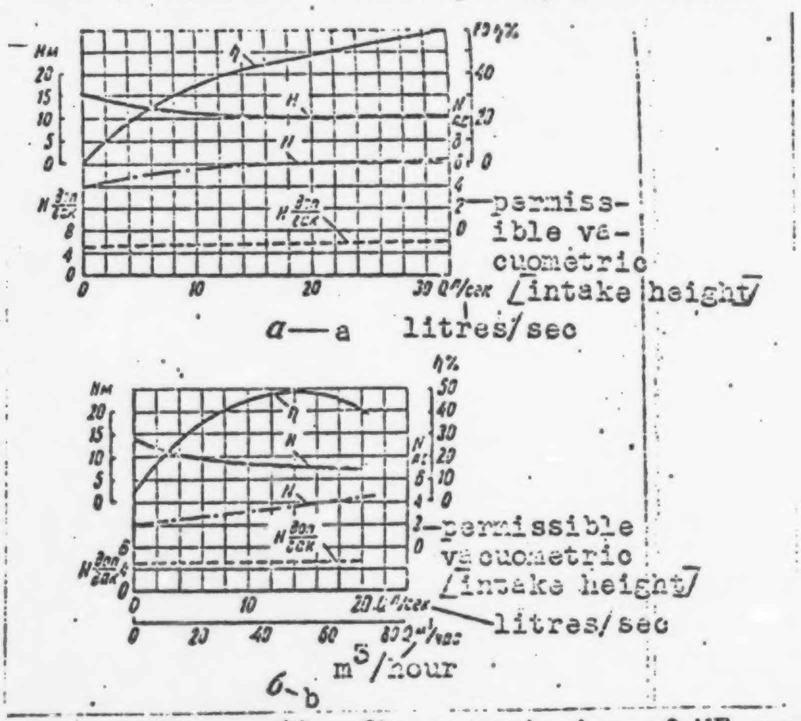


Figure 80 - Characteristics of NF pumps:
a - curves for 4NF pump where n = 975 rpm; b - curves for 2.5NF pump where n = 1,450 rpm.

Centrifugal pumps of the TsNSh type are single-stage and of the cantilever type with an operating wheel that has ∠196 a one-way intake.

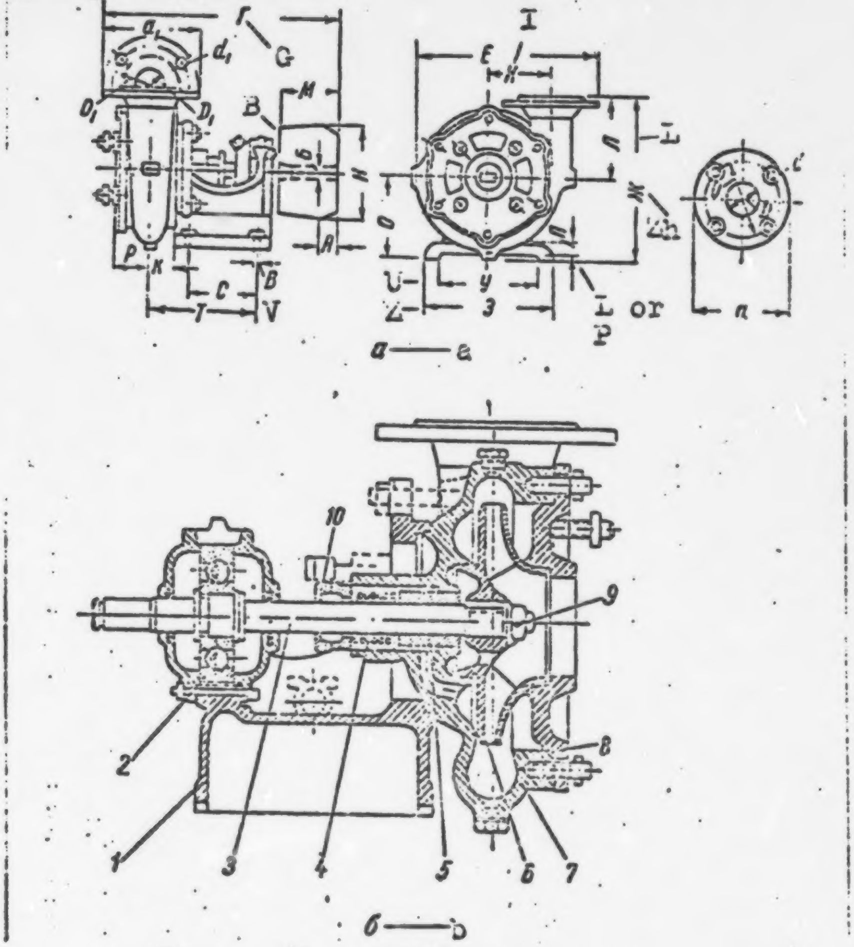

a₁
d₁
Г
G
D₁
B
M
H
P
K
C
T
V
A
E
I
L
Zh
U
y
З
Z
P
or
n
a——a
10
9
8
2
1
3
4
5
6
7
б——b

Figure 81 - TsNSh pump:
a - overall view; b - cross section

1 - frame; 2 - shaft bearing; 3 - shaft; 4 - stuffing box;
5 - bottom box; 6 wheel; 7 - pump housing (volute);
8 - housing cover; 9 - shaft nut; 10 - stuffing box cover.

These pumps are designed for pumping pure water of a temperature of up to 80°. They work well as priming pumps in fish-pumping units.

TsNSh pumps are manufactured in two model sizes; the TsNSh-40 and TsNSh-80 (the abbreviation TsNSh signifies /197 centrifugal pump, ball bearing [tsentrobezhnyi nasos sharikopodshipnikovyi]; the figure designates the diameter of the branch delivery pipe in mm).

The TsNSh pump (see Fig. 81) has a spiral housing that is fastened by dowels to a stand [frame]. The operating wheel of the TsNSh-80 pump is closed; the wheel of the TsNSh-40 pump, in view of its narrow width at the rim, is made without an external outer rim. The shaft has two bearings: a ball bearing in the stand, and a bronze bottom box.

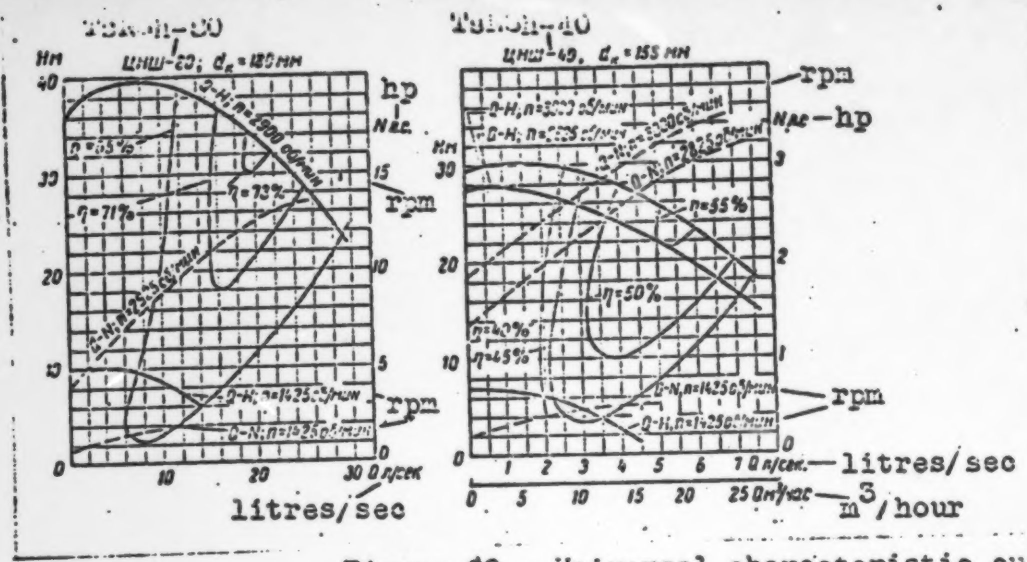


Figure 82 - Universal characteristic curves of TsNSh pumps.

The branch delivery pipe is directed vertically upwards, but can also occupy a horizontal position. The ball bearing is lubricated with grease. The stuffing box has a soft cotton packing. The stuffing box area communicates with the cavity of the pump by a channel, through which sealing liquid enters the stuffing box. The operating wheel has openings for easing the axle stress. The residual axle stress is taken up by the ball bearing.

The shaft rotates clockwise as viewed from the clutch side. TsNSh pumps are manufactured with a flexible clutch for direct connection to an electric motor.

The performances of the pumps (see Fig.82) include curves for the change in efficiency, and the curves Q - H and Q - N for various numbers of revolutions. The basic technical data and dimensions of TsNSh pumps are given in Tables 18, 19 and 20.

Table 18

Basic Technical Data for TsNSh Pumps (see Fig. 82)

Make of pump	Delivery		Full pressure head H, in m	Rpm of wheel	Power		Permissible vacuometric intake height H_{dop} /permissible/ in metres of a column of water	Efficiency of pump, in %
	in m^3 per hour	in litres per hour			shaft, in hp	of engine (recommended), in		
TsNSh ЦНШ-40	8,0	2,22	6,0	1425	0,41	1,0	7,0	43
	12,6	3,50	4,0	1425	0,43	1,0	7,0	43
	10,8	3,0	26,0	2925	2,26	3,2	7,0	46
	24,0	6,7	18,0	2925	3,36	3,2	7,0	45
TsNSh ЦНШ-80	28,0	7,80	10,0	1425	1,55	2,2	5,0	67
	49,0	13,60	6,0	1425	1,65	2,2	5,0	65
	50,0	13,9	38,0	2925	10,20	12,0	5,0	69
	103,0	28,7	24,0	2925	13,95	12,0	5,0	66

Table 19

Basic Dimensions of TsNSh Pumps in mm (see Fig. 81, a)

Make of pump	A	B	V	G	E	Zh	Z	I	K	L
TsNSh ЦНШ-40	25	20	18	385	285	270	200	102	42	145
TsNSh ЦНШ-80	30	28	18	445	350	311	225	118	46	153

Make of pump	M	N	O	P	R	S	T	U	Weight in kg
TsNSh ЦНШ-40	70	80	125	32	54	115	175	150	23
TsNSh ЦНШ-80	65	180	150	35	65	135	185	175	50

Table 20

Branch Pipes (see Fig. 31, a)

Make of Pump	Branch intake pipe (sizes in mm)				Number of bolts	Branch delivery pipe (sizes in mm)				Number of bolts	Size of suction valve (recommended) in mm
	D	a	b	d		D_1	a_1	b_1	d_1		
ЦНШ-40	50	140	110	M-12	4	40	130	100	15	4	100
ЦНШ-80 TsNSh	80	190	150	M-12	4	80	190	150	18	4	125

3. Diffusers /199

Apart from diffusers, which represent an integral part of the housing of a water-jet pump and are described in Chapter III, there are diffusers that are used jointly with centrifugal pumps.

In this case, their main purpose is to decrease the speed of the stream of fish and water emerging from the branch delivery pipe of the fish pump by a gradual increase in cross section; under this arrangement the kinetic energy of the stream is transformed in potential energy.

Diffusers with a conic cross section are generally used in fishing industry.

Professor P. A. Sviderskii[1] indicates that on the basis of experimental investigations the most advantageous value of a diffus efficiency is obtained where the central angle of its expansion (the angle of its conicity) is equal to 7 to 9°. When the diffuser is well made, its efficiency in this case usually amounts to 0.75 to 0.85, and goes as high as 0.95.

---

[1] Professor P. A. Sivderskii. Pumps for the Fishing and Canning Industries; State Scientific and Technical Publishing House for Food Industry [Pishchepromizdat], 1943.

The cross section of the truncated end of the diffuser cone, which adjoins the branch delivery pipe of a centrifugal fish pump, is made the same size as the branch [delivery] pipe itself. The length of the diffuser and the area of the cross section of the upper part of the cone depend upon the stream speed that must be obtained at the outlet of the diffuser.

The speeds of movement of the stream both in the intake and in the branch delivery pipes may be assumed to be equal (on condition that d_{vs} [intake] $= dq_{nagn}$ [delivery]

$$\text{vs}\ V_{\text{вс}} = V_{\text{нагн}}\ \text{nagn} \qquad [79]$$

Calculations for the diffuser can be made as follows. Having the area of the cross section of the branch delivery pipe, or, what is the same thing, the area of the lower truncated part of the diffuser cone, and the speed of the stream in this section, we determine the cross section of the widened part of the diffuser cone which would secure the required speed of the stream upon its emergence from the diffuser, and we also establish the height of the diffuser.

In the fishing industry at the present time centrifugal fish pumps are used whose branch delivery pipes are 100, 150, 200 and 250 mm in diameter. The areas of the cross sections of these branch pipes are 78.5, 176.6, 314 and 490.6 cm^2 respectively.

It is evident from the diagram of the diffuser shown in Fig. 83 that the angle $\beta = \frac{\alpha}{2}$, i.e., that it is equal to half of the central angle (the angle of conicity) of the diffuser; the angle β, in conformity with the above indications, /200 should amount to

$$\frac{7^\circ}{2} = 3^\circ 30'; \quad \frac{8^\circ}{2} = 4^\circ; \quad \frac{9^\circ}{2} = 4^\circ 30'$$

or should be equal to their intermediate values. Further, it may be seen from the diagram that

$$\frac{b}{h} = \operatorname{tg} \beta,$$

whence

$$h = \frac{b}{\operatorname{tg} \beta}, \quad b = \frac{d_1 - d}{2}.$$

The speed and the area of the cross section of the stream are inversely proportional and are in linear relation.

Thus where it is necessary to decrease the speed of the stream by n times, the area of its cross section must be increased n times, and vice versa.

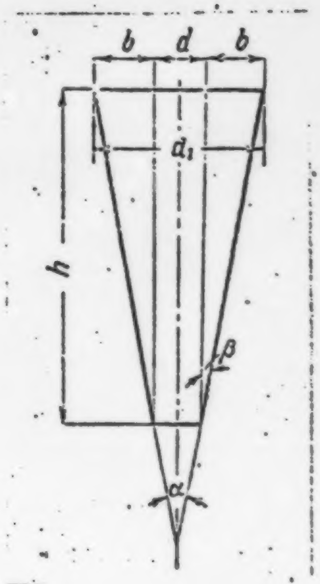


Figure 83 - Diagram of diffuser.

A description of the use of a diffuser in a ship fish-pumping unit is given in Chapter IX.

4. Water Separators

When a mixture of fish and water is conveyed through hydraulic conveyers - in open troughs or in pipes - before the fish arrives for processing it must first be separated from the water and further conveyed in /an externally/ dehydrated form. The same thing must be done when fish is transshipped by fish pumps from fishing gear into transport ships.

Devices called water separators are used for dehydrating fish. The water separators used in the fishing industry are fairly diverse in design, but they may be grouped into two main categories. The first category includes water separators that do not require the use of driving attachments. The water separators of the second group, on the other hand, require the use of such attachments.

The water separators in the first category may be divided into water separators in the form of pans or troughs with slotted or perforated bottoms, and water separators of the cascade type.

Water separators with slotted bottoms are used mainly at enterprises in the Far East for large and medium fish (chum, pink salmon, herring etc). The solid bottom of the trough /201
is replaced by longitudinal strips fastened parallel and placed at some distance from each other. Under the sector of the trough where the water is separated is a pan in which the water running off the fish is removed. An overall view of such a water separator is given in Fig. 84.

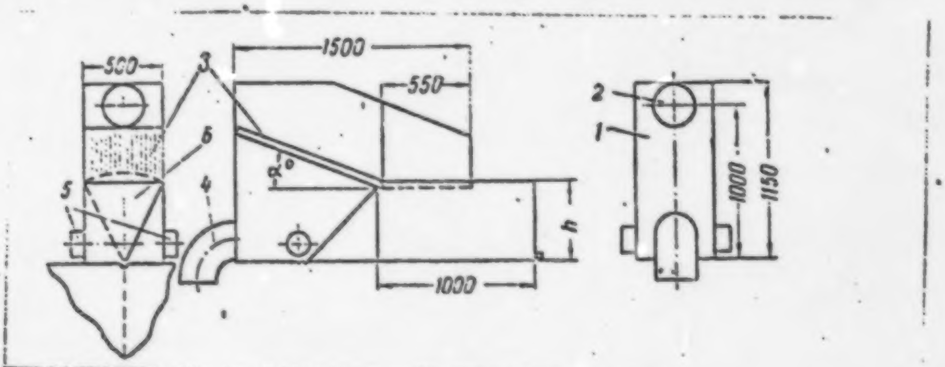


Figure 84 - Diagram of a strip water separator:
1 - casing; 2 - intake opening; 3 - grating; 4 - branch pipe for discharging water; 5 - branch pipe for auxiliary hoses; 6 - hinged gate.

LIBRARY
FISHERIES RESEARCH BOARD OF C
VANCOUVER LABORATORY
6640 N.W. MARINE DRIVE
VANCOUVER 8, B.C.

The distance between the strips may be altered depending upon the size of the fish that are being conveyed.

After the fish have been [externally] dehydrated, they fall onto an inclined chute and can move either in the same direction or can slip off to one or another side of the axis of the trough on corresponding inclined chutes.

Inclined trough water separators of the same type with slotted bottoms are widely used at herring fish plants in the Far East. The working part of the water separator is made of metal rods or wooden strips placed lengthwise. The inclined trough water separator itself is installed at an angle of 30°.

The Sakhalin Division of TINRO has carried out production tests on a number of inclined trough water separators of different designs and has established the optimum angles of inclination of the troughs, their length, and the quantity of water carried away by fish in percentages of the weight of herring when it passes through troughs of different lengths. The results of the tests are given in Table 21.

As a result of the tests, it has been established that:

1) the most complete separation of water takes place on inclined trough water separators with a longitudinal arrangement of wooden strips or metal rods with a distance between them of 10 to 12 mm, where the trough is 1.4 to 1.5 m /202

long and where it is installed at an angle of 30°;

2) the quantity of water mechanically carried away with a stream of herring should not exceed 3% of the latter's weight; in addition, on the surface of the herring is a quantity of water equal to 1% [of the weight of the herring]. The quantity of water mechanically carried away depends upon the design of the water separator, while the quantity of water on the surface of the herring depends upon the specific surface of the herring.

Table 21

Data of Tests of Trough Water Separators

Design of trough	Angle of inclination, in degrees	Quantity of water carried away by fish in percentage of latter's weight, where length of trough is		
		1,0 м	1,2 м	1,4 м
Longitudinal metal rods ...	30	3,8 4,0	2,8- 3,0	2,2–2,6
Transverse rods above and longitudinal rods below ...	30	4,2–5,0	3,1–3,3	2,4–2,9
Longitudinal wooden strips	30	—	2,5–2,9	2,1–2,4
Transverse metal rods	35	4,3 5,5	3,1–3,5	3,5–3,6
Combined arrangement of metal rods	35	5,3	5,3–6,6	4,0–4,3
Combined arrangement of wooden strips	35	—	—	4,5–7,0

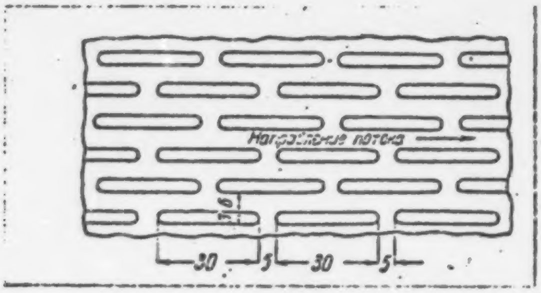


Figure 85 - Diagram of perforation of trough water separator.

Water separators used for smaller fish - anchovy, tiulka and Baltic herring - represent one variety of water separators with perforated bottoms. They are installed as follows.

The trough of a hydraulic conveyer in the sector where the water separation takes place is made of galvanized sheet iron in the same cross section as in the remaining part of the trough (rectangular or with a semi-circular bottom). Openings are punched in a specific order in the bottom and wall of the water separator.

For anchovy and tiulka, oval openings 30 mm long and 5 mm wide have proven to be the most advisable. The openings are arranged in staggered rows at intervals of 6 mm each in a longitudinal direction (see Fig. 85).

The openings can be larger for larger fish (Baltic herring). The most advisable size of opening can be selected on the basis of experimental work. /203

Water separating troughs with a perforation similar to that indicated above, are also used in some fish-pumping units on board ship.

Calculations for a latticed water separator with a low incline (20 to 30°) can be made from the formula

$$F=\frac{Q_y}{\varphi v_y}, \qquad [80]$$

where: F is the sum of the areas of the grating openings, or the cross section in m^2;

Q_y is the flow rate of the water carried away through the grating, in m^3/sec;

φ is the coefficient of compression of the stream when it is passing through the openings of the grating; Chernigin recommends that φ be taken as = 0.9;

v_y is the average speed at which water flows through the openings of the grating in m/sec, normal to the surface of the latter (it is recommended for calculations that v_y be taken as = 1.1 m/sec).

If we know the area of the cross section and assign linear dimensions for each opening which will prevent fish from becoming jammed in them, it is not difficult to determine the quantity of openings n and the linear dimensions of the grating

$$n=\frac{F}{f}, \qquad [81]$$

where f is the area of one opening.

Where fish are conveyed with water for considerable distances through metal pipes, and also where net frames are unloaded in an open roadstead with the aid of centrifugal fish pumps, water separators of the closed type are required in which there will be a partial removal of the water from the mixture without decreasing the latter's pressure head. When passing through centrifugal fish pumps, the mixture of fish and water has, as a rule, a proportion of 1:5 to 1:10. Under these conditions, injury, in particular, to fish unloaded by centrifugal fish pumps is kept to a minimum (where the lift is normal).

A fish-to-water ratio of 1:3 to 1:4 is quite sufficient for the normal movement of a mixture of fish and water in a steel conduit. Where there is excessive water, the volume and speed of movement of the mixture through the pipes increase.

All losses of energy during the movement of liquid in a fish conduit are proportional to the square of the speed of movement. Consequently, a two- or three-fold increase in the speed involves a four- or nine-fold increase in losses /204 of pressure head. A closed water separator, set up after /the installation of/ the fish pump and removing excess water from the mixture of water and fish, decreases energy losses. Moreover, the water which has been drained off can be used for flooding fish in ships' holds or for other purposes.

A closed water separator for centrifugal fish pumps (see Fig. 86), proposed by N.F. Chernigin, is simple to install. The diameter of the inner metal pipe is equal to that of the fish conduit, and the diameter of the outer pipe is 100 to 150 mm (greater than the diameter of the fish conduit). The ends of the outer pipe are stopped up and are welded to the inner pipe; in this way, a waterproof jacket is formed. On the outer pipe is a cock for releasing air from the jacket, and a branch pipe with a regulating valve. The amount of water removed from the mixture is regulated with the valve. The diameter of the valve is selected in conformity with the quantity of water that is being removed.

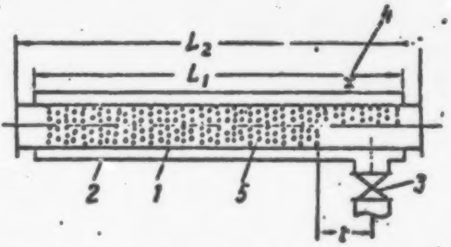


Figure 86 - Closed water separator:
1 - inner pipe; 2 - outer pipe; 3 - regulating valve; 4 - air cock; 5 - openings.

Along the periphery of the inner pipe is drilled a large number of openings through which the water from the fish-and-water mixture passes into the jacket and further on is discharged through the valve.

It is recommended that the openings be made with a diameter of no more than 8 to 10 mm when small fish are being pumped through the fish conduit, and no more than 20 mm when large fish are being pumped. The openings are punched or drilled in the steel sheet before the pipe is welded. Care must only be taken that the side of the pipe with projecting edges is turned towards the jacket in order to avoid damage to the scales of passing fish.

In order to secure the best conditions for the discharge of water through the holes located opposite the valve, and so that the fish will not adhere to the wall of the pipe in the half of the latter that is turned towards the valve, no holes must be drilled throughout the length of the pipe, which is equal to two or three times the diameter of the valve.

Openings must be arranged in staggered rows at distances of four to five diameters from each other. The length of the pipes L_1 and L_2 is determined in accordance /205 with the necessity for a uniform distribution of the entire quantity of openings.

Cascade water separators are widely used both in ship and in shore units in the Azov, Black Sea and Caspian Basins.

From the constructional point of view these water separators are divided into two-cascade and four-cascade.

Among the former (see Fig. 87) are round water separators made according to the proposals of Topchienko and Sakharnov, the Specialized Directorate for Construction and Installation in the Fishing Industry*, and Petrenko; among the latter (see Fig. 88) are rectangular water separators made according to a proposal by the State Institute for the Planning of Enterprises and Machinery of the Fishing Industry [Giprorybprom].

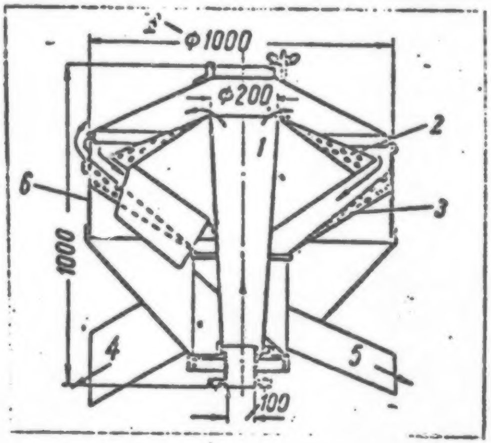


Figure 87 - Two-cascade water separator:

1 - diffuser; 2 - rack of first cascade; 3 - rack of second cascade; 4 - branch pipe for discharging fish; 5 - branch pipe for drawing off water; 6 - jacket.

The operating principle of these water separators is as follows: the mixture of fish and water is fed from the fish delivery conduit into the two-cascade water separators from below, into a diffuser passing through the water separator, and into the four-cascade separator from above.

---

* Translator's note. A suggested rendition of the Russian Spetsmontazhrybstroi.

Upon emerging from the upper, widened, part of the diffuser, the mixture of fish and water, having considerably less speed, strikes a divider that distributes the stream evenly, through the upper truncated cone, which is perforated for discharging water. The water runs off through the openings onto a dead-end truncated cone located under the upper perforated cone. The partially [externally] dehydrated fish slips off onto a second perforated, truncated cone, where the water is finally separated from it; the water runs off /206 into a cavity bounded by a second dead-end truncated cone, into which the water from the upper dead-end cone also drains.

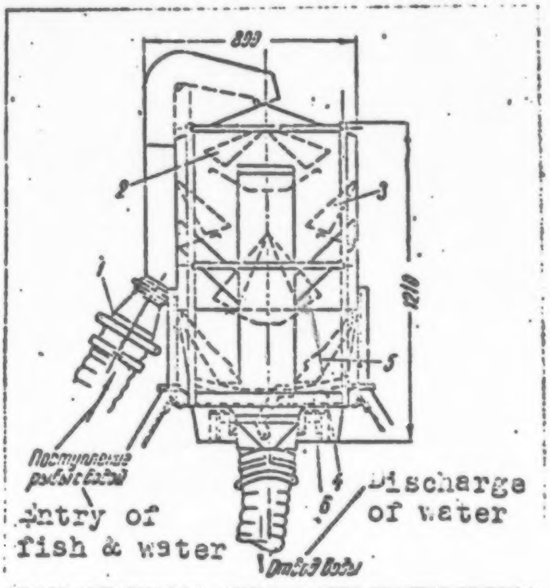


Figure 88 - Four-cascade water separator:

1 - hose for conveying mixture; 2 - rack of first cascade;
3 - rack of second cascade; 4 - rack of third cascade;
5 - rack of fourth cascade; 6 - chute for discharge of fish.

The water is diverted to the side through an outlet on which is usually put a rubber hose, and the [externally] dehydrated fish moves down an inclined trough for further processing.

In four-cascade water separators the angles of inclination of the three upper perforated cascade racks may be varied within the range of 10 to 15°.

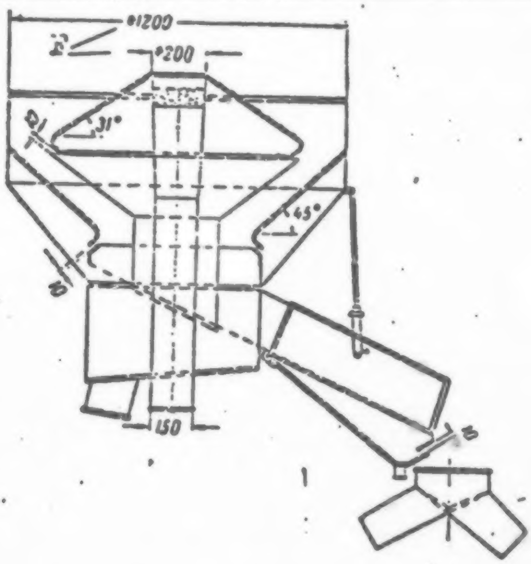


Figure 89 - Improved two-cascade water separator designed by Petrenko.

Comparative tests of cascade water separators carried out at the Don-Kuban Fisheries Station of VNIRO, have shown that two-cascade water separators of the Petrenko system, improved by the Fisheries Station itself, give the best results.

The following changes have been made in the improved water separators designed by Petrenko (see Fig. 89); all openings are funnel-shaped, promoting good separation of water; the water separators are collapsible and are easily accessible for cleaning; the lower edges of the perforated cones and chutes are rounded, which ensures the best runoff of the water; the angles of inclination of the upper perforated cones are equal to 30 to 35°, and the corresponding angle of the lower perforated cones is 45°.

Where such water separators are properly operated, /207 they separate up to 95% of all water, which can be considered to be entirely satisfactory.

Reticulate conveyers and vibrator water separators belong to second-category water separators using mechanical drives.

Water separation is good on reticulate conveyer-water separators in which perforated plates or a metal net serve as a water-separating grating. A characteristic feature of these water separators is that in them a stream is motionless relative to the water-separating net and moves together with the latter, undergoing, in the process of movement, a certain jarring owing to the irregular movement of the /conveyer/ chain.

A reticulate conveyer-water separator (see Fig. 90, a) consists of a chain conveyer with a flat belt made of metal net with a rectangular mesh measuring 5 x 5 mm. The belt is edged with wire at its ends and across. Round tension members in the form of small rods preventing the constriction of the belt are installed at intervals across it. The conveyer has flanged edges along its belt and a hopper. Unloading is carried out through a driving drum. Under the belt is an inclined sheet iron pan for collecting water.

The reticulate conveyer-water separator (see Fig. 90, b) differs from the preceding [type of equipment] in its dimensions and in the fact that it has no hopper. It is installed with an incline of approximately 15 to 20°.

Technical Description of Reticulate Conveyers

	With hopper	Without hopper
Discharge of fish in tons per hour ...	up to до 18	12
Speed of belt in metres per second ...	0,40	0,6
Width of belt in metres	0,75	0,6
Distance between axes of sprockets, in metres	7,04	5,1
Power of electric motor in kw	2,5	2,2
Weight of conveyer in kg	800	523

Jarring water separators are to be found at enterprises in the Azov-Black Sea area. A jarring water separator consists of a perforated metal sheet with sides and a bottom pan set on flexible wooden posts (of beech or ash) and connected to a transmission that sets it in vibrating motion. The water-separator grating has round openings (75 openings per square decimeter) each 5 mm in diameter.

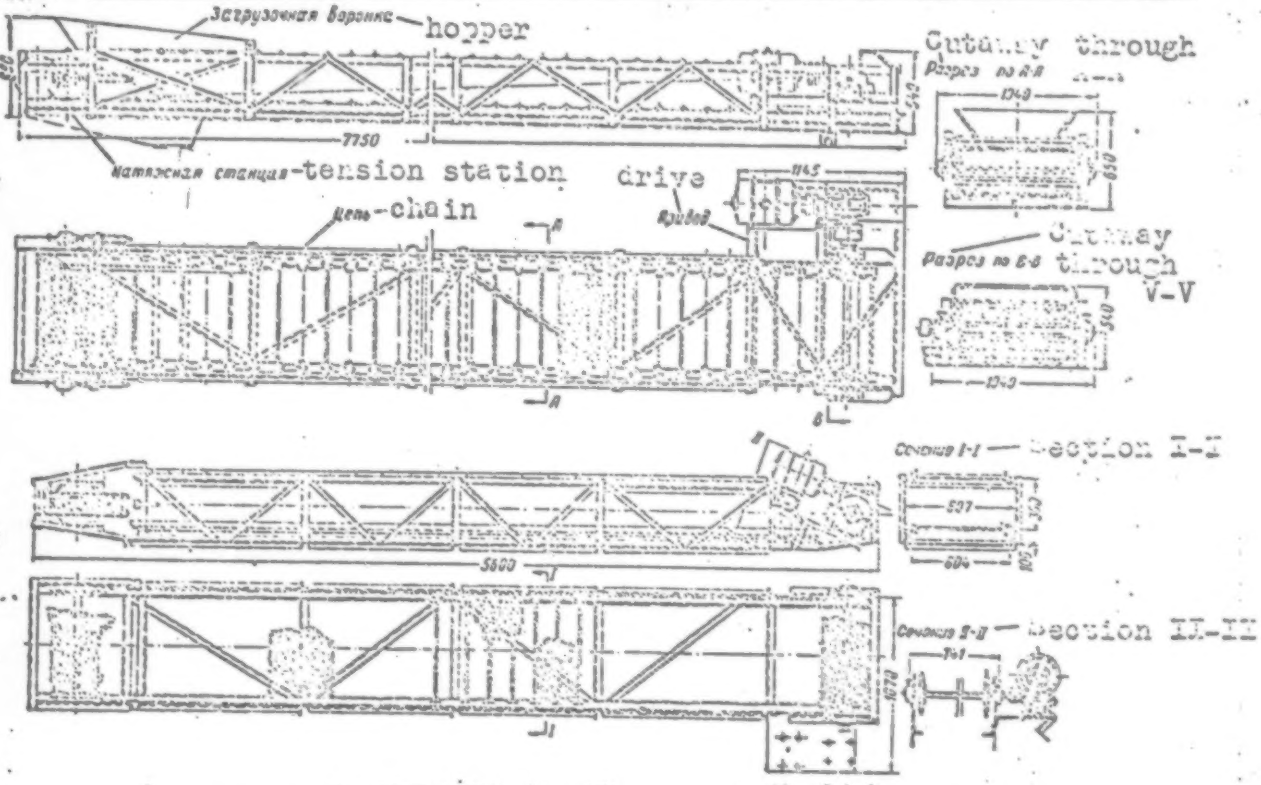

Загрузочная воронка—hopper
Cutaway through A-A
Разрез по А-А
1340
650
7750
1145
а
Натяжная станция-tension station
drive
Привод
Цепь-chain
Cutaway through V-V
Разрез по Б-Б
540
1340
Сечение I-I — Section I-I
537
604
б
5800
Сечение II-II — Section II-II
1070

Figure 90 - Reticulate conveyer-water separator: a - with hopper; b - without hopper.

The power of the water separator motor is about 1.5 kw. /209

During tests, a jarring water separator designed by Gorbunov demonstrated that it could work steadily with a discharge of 15 tons per hour of anchovy.

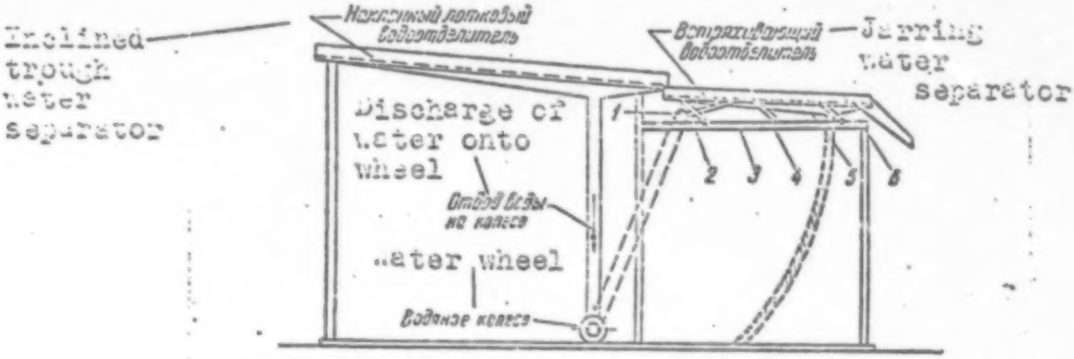

Inclined trough water separator
Наклонный лотковый водоотделитель
Встряхивающий водоотделитель
Jarring water separator
Discharge of water onto wheel
Отвод воды на колесо
Water wheel
Водяное колесо
1
2
3
4
5
6

Figure 91 - Trough-type and jarring water separator:

1 - pulley; 2 - eccentric; 3 - frame; 4 - post; 5 - bottom pan of trough; 6 - perforated trough.

Paired trough and jarring water separators (see Fig. 91) are in operation at enterprises in the Estonian Soviet Socialist Republic. The water from the trough water separator rotates a turbine, from which the jarring water separator is set in motion.

Chapter IX

HYDRAULIC ENGINEERING IN THE CATCHING OF FISH

1. General Remarks /210

In the USSR the question of using hydraulic engineering in the fishing industry [for catching] was first raised in 1932 and was dealt with in published form in 1934 by N.D. Kholin (Publications of the State Hydrological Institute).

The first time that a fish pump was actually used for unloading fishing gear was in 1939 at the Oranzherei Fisheries Combine in the Volga-Caspian Basin. A water-jet pump was installed on a non-self-propelled vessel - a seiner (see Fig. 92) - and served to transfer a fish catch from a drag seine into a live fish carrier.

In Dagestan in 1940 a centrifugal fish pump (see below) was used for unloading catches of herring from a drag seine. The same fish pump was used in 1940 for unloading /211 catches from purse seines and trap nets on the Azov and Black Seas. The favourable results of the work of the fish pump in unloading the fishing gear greatly expanded the use of this method of unloading. The number of units in operation has increased continuously.

In the Far East the method of delivering live fish in floating net bags from seines to shore or roadstead fish-pumping units has been widely used.

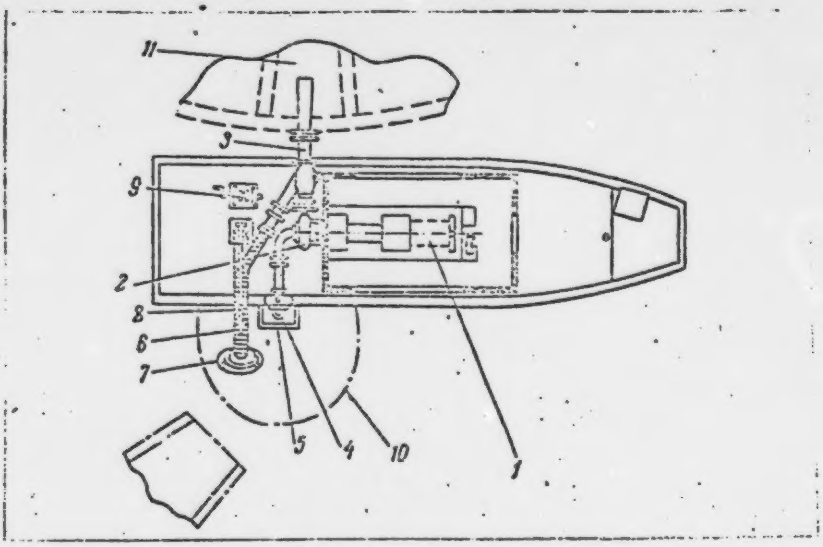


Figure 92 - A floating water-jet fish pump unit for unloading fish from seines:

1 - STZ-NATI tractor engine; 2 - centrifugal pump; 3 - water-jet fish pump; 4 - water intake conduit with return valve; 5 - wooden enclosure; 6 - intake hose; 7 - enclosure of intake hose; 8 - boom; 9 - winch; 10 - seine bag; 11 - live fish carrier.

The electric catching of fish, with the use of a fish-pumping unit as a catching and unloading facility, has been tested under industrial conditions on the Yavina River (Kamchatka).

Finally, the successful use of underwater electric lighting for attracting fish, which are simultaneously taken directly from the sea (in the Caspian Basin) with fish-pumping units mounted on board ship, indicates the wide and effective use of hydraulic engineering in the catching of fish.

The efficiency of using fish pumps to unload fish from fishing gear and ships and to take fish directly from the water, varies and is reflected in different [production] figures. On the one hand, there is a decrease in the input of physical labour on the part of the workers, and, as a result, a direct decrease in the cost of transshipping a ton of fish. On the other hand, as a result of the acceleration of the process of unloading fish with a fish pump, as compared with ordinary methods, the fish are in better condition, there is a decrease in losses and in the turnaround time of the fleet, and wear and tear on the latter is reduced. Where fish pumps are used, there is a significant increase in the utilization of fishing gear per unit of time, as a result of which there is also an increase in the total quantity of fish taken for processing, and the quality of the product improves.

An acceleration in the utilization of fishing gear per unit of time and an increase in the catch per unit of such equipment yields a considerable saving in fish net material per ton of fish caught.

None of these figures pertaining to efficiency has yet been taken into account with the usual methods of calculation, although they constitute a basic value in the efficiency of mechanization.

2. Unloading Fish from a Drag Seine with a Fish Pump

An experiment in the use of a water-jet fish pump for unloading fish from a drag seine was repeated in 1942 in Kamchatka.

The fish pump was set up directly at the river, beside the fish-receiving platform of a cannery. The fish were unloaded from the drag seine with a rubberized intake hose 250 mm in diameter and 16 metres long. The mixture of fish and water was directed from the fish pump to the fish-receiving platform through a hydraulic conveyer made of a wooden /212 trough. The height of the platform above the level of the water in the river was 3 metres.

The fish-pump unit differed in no way from an ordinary stationary unit for unloading fish from ships. A special grating for preventing the net from being drawn in was put on the spout of the intake hose (see Fig. 75).

The seine containing the fish was hauled in* by a crew of fishermen. As the fish were pumped out of the seine bag, the fishermen partially dried the net, i.e., they raised the edges of the bag slightly above the water by hand, so that the fish were driven in the direction of the spout of the intake hose.

---

* Translator's note. A suggested rendition of the Russian pritonenie, for which no other suitable equivalent is available.

After the seine was hauled in and a rubber intake hose lowered into the bag, the fish pump was started and the unloading proper began. The fish in 12 seconds, during which they were in the hose and the fish pumps, arrived in water live and without injury at the fish-receiving platform.

A fish catch of 50 to 60 centners [5,000 to 6,000 kg] was unloaded at the platform in 3 to 3.5 minutes. In this case, the discharge of the fish pump amounted to ≈ 1,040 centners [104,000 kg] per hour.

3. Unloading Fish with a Fish Pump from the Hearts of Trap Nets into a *Kungas* and from a *Kungas* onto the Shore

A so-called turnover *kungas* is stationed at right angles to trap nets for unloading their hearts.

Along the side of the turnover *kungas* is a crew of 12 to 14 fishermen, who raise by hand the bottom of the heart from any one side. By manually turning over the bottom of the trap, the crew of fishermen drives the fish that have been caught to one side of the heart, where there is a cargo *kungas* that has been prepared in advance and into which the fish are poured from the heart, usually by hand with the aid of a neg bag [*Kapler*].

Since there is already a ready-made mixture of fish and water in the heart, the use of a fish pump is quite feasible.

The mixture of fish, however, cannot be fed into the kungas - the fish must first be separated from the water.

For this purpose, the ordinary floating fish-pump unit on board the kungas is supplemented with a water separator in the form of an inclined trough 3 metres long with a latticed /grate/ bottom and a bottom pan for the length of the trough, which is two metres. The end of the grating projects beyond the side of the kungas on which the fish pump has been mounted. The fish are directed into the hold of the cargo kungas standing alongside.

The trough is installed at an incline of 30° after the circulation tank /has been set up/. The fish, entering this trough in water, continue to move along the inclined grating even after the water has been separated. The water that has passed through the grating is caught by the bottom pan and is carried over the side through a canvas hose. /213 Rolling down the water separator grating, the fish enter the cargo kungas still alive.

Tests carried out in 1945 at the Anapa Fisheries Combine on a floating unit in unloading herring and salmon from the hearts of trap nets, demonstrated that the unit is entirely suitable for this purpose.

An obstacle to the wide introduction of fish pumps for unloading fish from trap nets has been the fact that no systems of mechanization have yet been developed for turning over the trap net; nor has a way been found to mechanize other methods of driving the fish towards the intake hose of the fish pump.

4. A Floating Fish-Pump Unit for Work on Rivers

A floating fish-pump unit has been used for receiving fish from river catches.

Fluctuations in the water level, which owing to tides reached 3.7 metres, were creating extremely great difficulties for the /Anapa/ Combine in the unloading of fish-carrying kungasy. The considerable distance to which the water retreated from the fish-receiving platform at low tide owing to the slope of the shore, did not permit the kungasy to be unloaded by being dragged from the river onto the shore. At the same time, the main influx of fish from the fishermen was just at low tide, since during this period it was convenient to catch fish. The Combine had to delay the receiving of fish from the fishermen until the water approached the fish-receiving platform at high tide, and to unload the kungasy by throwing the fish by hand down upon the platform from a height of 4 metres above the level of the river.

Water-jet fish pumps could not work where there was such a lift; therefore the unit had to be put on board ship: /the ship carrying/ the unit had to be anchored in the middle of the river opposite the fish-receiving platform, and the fish-carrying kungasy unloaded by being brought directly up to the kungas on which the fish pump was mounted.

Several piles were driven into [the river bottom in a row] leading from the shore to the fish pump.

The row of piles ended in a small platform, on which was mounted an inclined scraper conveyer.

The mixture of fish and water unloaded by the fish pump from a kungas, was passed through a trough to the scraper conveyer. The water ran off, and the fish were lifted into the hydraulic conveyer and then proceeded to the fish-receiving platform. The hydraulic conveyer was supplied with water by the centrifugal pump of the water-jet fish pump. The conveying trough of the fish pump was not connected to the scraper conveyer; therefore the unit on the kungas could move vertically along with the fluctuations in the level of the river. As a result, the fish moved from the fish pump through the trough while the scraper conveyer was at different heights corresponding to the water level in the river, which had no effect on the operation of the scraper conveyer.

In order to create continuity in unloading, the /214
loaded kungasy were moored not around the fish-pump unit, but rather at a special buoy established at a distance of 100 metres upstream. From the buoy the kungasy were released

to move to the fish pump along a cable specially extended downstream. After being unloaded, the kungasy moved downstream from the fish pump.

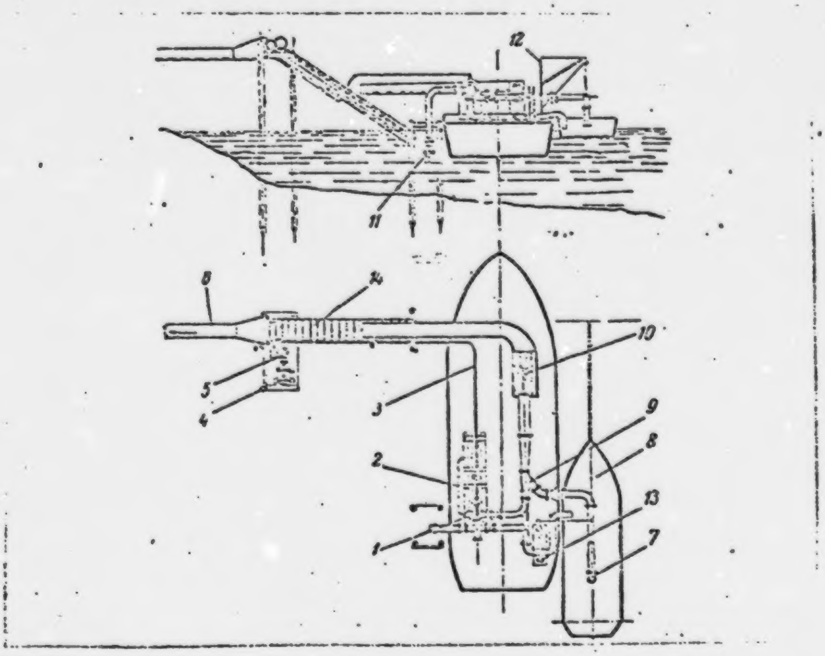


Figure 93 - A floating water-jet fish-pump unit for conveying fish to a hydraulic conveyer on shore:

1 - centrifugal pump; 2 - pipe for cooling; 3 - pipe for supplying water to the hydraulic conveyer; 4 - electric motor; 5 - reducing gear; 6 - hydraulic conveyer for conveying fish to the processing area; 7 - intake pipe; 8 - kungas; 9 - mixing chamber; 10 - water separator grating; 11 - suction valve; 12 - cargo crane; 13 - clamp; 14 - scraper conveyer.

This fish pump unit is even now operating successfully at the fisheries combine, unloading kungasy carrying fish caught in the river (up to 70,000 centners [7,000,000 kg] annually).

The use of the floating unit has resulted in the release of 42 workers who had previously been occupied in the production processes involved in the manual unloading of fish; the turnaround time of the kungasy was decreased: the time taken to unload these vessels was reduced to 3.5 to 5 minutes as against the 1.5 to 2 hours required when manual methods were in use; it became possible to unload kungasy at any time irrespective of the tides. In addition, when the floating unit was used, the wharf and the kungasy were copiously washed with water, as a result of which their sanitary condition was greatly improved. When loading was carried out by fish pump, there was a decrease in losses of fish, since in hand unloading 2 to 3% of the fish did not reach /215 the fish-receiving platform when they were thrown down, and fell into the water under the wharf.

After the fish had passed through the fish pump, a hydraulic conveyer delivered them to the processing plant, which was at some distance from the shore.

5. Unloading Herring from the Heart of a Trap Net Using a Net Corridor and a Fish Pump

An experimental unit was developed and produced for mechanizing the unloading of herring from the heart of a trap net.

The entrance to the heart of the trap net was widened. Not one wing (a "central" /passage/) but two were extended from the heart in the direction of the shore. The lower parts of both wings were tightly joined, forming a net corridor, as it were, from the heart of the trap net to the surf zone at the shore.

At the end of the net corridor was placed the intake pipe of the fish pump. The spout of the fish-pump intake pipe was equipped with a protective grating similar to that used in unloading from drag seines.

The intake pipe conveyed the mixture of fish and water from the net corridor through the surf zone to a stationary fish pump installed on shore. The mixture was fed from the fish pump to a circulation tank, then to a scraper conveyer, and moved through a system of hydraulic conveyers toward the pickling tubs. Here the water was removed to the sewage system through drains, and the fish rolled down the inclined grating directly into the pickling tubs.

An experimental installation including a net corridor and a water-jet pump was produced and tested in 1947 at the Anapka Fisheries Combine. It was assumed that such a unit would improve the use of the hearts of trap nets by reducing the time taken to unload the catch, that it would make the entire process like that of an assembly line, and that it would permit the fish to be delivered live to the fish plant.

These assumptions were for the most part justified. When, however, the unit that we have described was used, the consumption of fish net materials increased sharply; moreover, the turning over of the net corridor was more laborious than turning over an ordinary heart. In 1953 the net corridor was replaced by a combined two-stage fish-pumping unit using the NCh-3 and RB-250 fish pumps.

6. The Use of Centrifugal Fish Pumps for Unloading Fish from Drag Seines in Dagestan

In Dagestan a drag seine is usually hauled in to shore at different points along the shoreline, with a distance of up to 200 m between the end points. The installation on the shore of a stationary fish-pumping unit for unloading fish from the bag of a drag seine, causes considerable difficulty, /216 since it becomes necessary to use intake hoses of a length that exceeds the intake capabilities of the fish pumps.

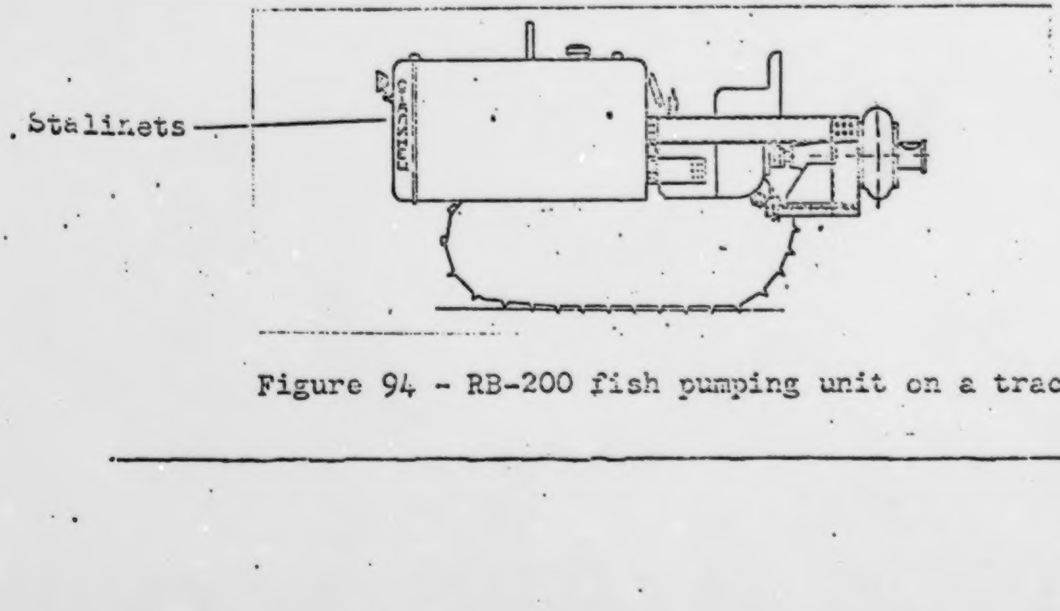


Figure 94 - RB-200 fish pumping unit on a tractor.

In such cases, good results are obtained from using mobile fish-pumping units.

Owing to the comparatively small dimensions and light weight of a centrifugal fish pump, it can be mounted on a tractor. In this case, the fish-pumping unit becomes fully mobile and can unload a drag seine immediately at the place where it is hauled in. Through the use of steel delivery conduits, to which the rubber delivery hose of the fish pump is connected, the fish that is unloaded is conveyed directly to its processing area by the same fish pump.

A fish-pumping unit of this kind was used at one of the fish plants of the Dagestan Fisheries Trust in 1940 for unloading herring from drag seines during work on a very gently sloping shore of the Caspian Sea.

An RB-200 fish pump was mounted on a Stalinets-60 caterpillar tractor from behind the driver's seat on a special channel-bar frame that was fastened to the frame of the tractor (see Fig. 94).

The operating wheel of the fish pump was rotated by the power take-off shaft of the tractor through a clutch. The 16-metre-long intake hose had a return valve at its end. Before it was started, the fish pump was primed with water from a tank through a two-inch water conduit laid along the shore in the area where the drag seine was hauled in. The tank was installed on the shore at a certain elevation. The delivery hose of the fish pump was up to 24 metres long and was connected to the nearest T-pipe of the delivery conduit, also laid along the shore in the direction of the fish processing area. (see Fig. 95).

The fish were unloaded as follows. After the drag seine was hauled in, and the bag of the seine was lifted /217 slightly in order to achieve the required concentration, the tractor with the fish-pumping unit approached the place where the seine was hauled in. The tractor engine was switched to the power takeoff shaft, and the flexible intake hose of the fish pump, 200 mm in diameter, was lowered into the middle of the bag. Here the hose was arranged in such a way that its snore piece was located not too close to the surface of the water, so as not to draw in air, and not too close to the bottom, in order to avoid sucking in sand. So as to fulfill these requirements, the intake hose was laid on chocks installed in the bag of the seine. The depth of the water at the place where the seine was hauled in was not less than 0.3 to 0.5 metres.

After the fish pump and the intake hose were primed from the priming tank, the fish pump was turned on and it began to pump a mixture of fish and water from the seine bag into the delivery conduit. The desirable fish-to-water ratio of 1:4 was achieved by lifting the seine bag slightly as the fish were unloaded from it.

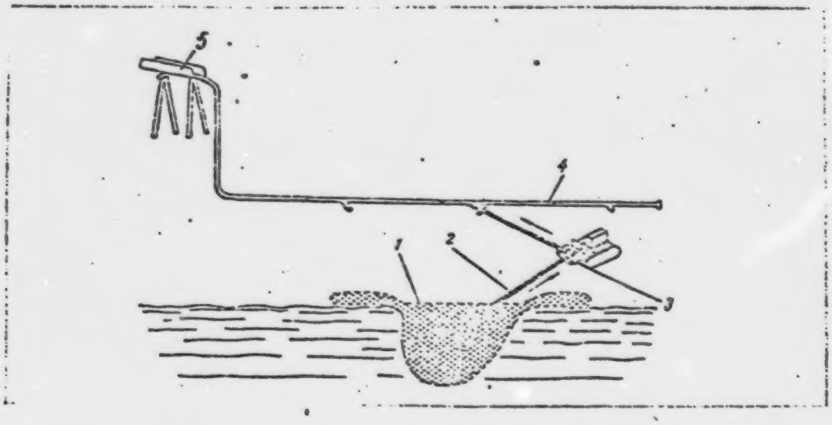


Figure 95 - Diagram of hydraulic mechanization of unloading fish in Dagestan:

1 - seine bag; 2 - intake hose; 3 - fish-pumping unit;
4 - fish delivery conduit; 5 - hydraulic conveyer.

The delivery hose of the fish pump was connected to the nearest T-pipe, which was installed on the metal delivery conduit laid along the shore. The T-pipes placed along the path of movement of the mixture of fish and water were applied not at a right angle, but at acute angles (30, 45, and 60°.

The intake conduit, 200 mm in diameter, was laid horizontally along the hauling strip, and then rose 8 metres in a smooth bend and proceeded towards the pickling shed, in front of which were installed a hydraulic conveyer and water separators. The speed at which the mixture moved through the conduit was about 2.4 m/sec and through the hydraulic conveyer, about 1 m/sec.. All the suspended sand, therefore, which /218 had been drawn in by the fish pump from the seine bag together with the water and fish,, was deposited in the hydraulic conveyer.

Where the basic requirements for the correct operation of a fish pumping unit were fulfilled (rpm of fish pump - 600 to 700; fish-to-water ratio in the pumped mixture - 1:4; correct placing of the intake hose in the seine bag; careful fitting of the conduits), injury to the pumped fish was no more than 1%. The chief injury consisted in slight ruptures of the gill covers (knocked-off scales are not considered a flaw in herring). About 90% of the fish that were transshipped entered the vats alive after having passed through the entire system. The discharge of the unit was, on the average, 60 tons of fish per hour.

It was at one time intended to make certain additional improvements in mobile, tractor-mounted fish-pumping units. For carrying the hoses it was proposed to use a cart (towed by the tractor), on which would be installed a manual crane for lowering the intake hose into the seine bag and maneuvering it during unloading. Operational experience revealed certain difficulties that were encountered when these operations with intake hoses were carried out manually. In addition, it was proposed to abandon the use of a return valve at the end of the intake hose, in which connection it was planned to install a manual piston pump of the Garda type (small size) on the tractor, as well as a return valve on the branch delivery pipe of the fish pump. The use in this case of a water-circulating vacuum pumpcaused certain constructional difficulties.

None of these intentions, however, has so far been realized.

7. The Use of Centrifugal Fish-Pumping Units for Unloading Fish from Purse Seines, Trap Nets and Alamans* on the Sea of Azov

Fish are usually unloaded from purse seines, after the latter have been closed, with the aid of a net bag - a sak or a kapler. The fish are scooped out of the seine with a kapler and are raised on board the ship with a ship's winch. In some cases, the fish are unloaded from the above fishing gear by hand with a lift net called a zyuz'ga or a kital. These methods of unloading, particularly the last, are inefficient and laborious. The use of fish-pumping units for unloading fish from purse seines is the most efficient.

A centrifugal fish pump is installed on the deck of a motor ship and is operated by the ship's engine. The fish that are being unloaded are strained from the water and enter the hold of the transport ship, which is moored to the side of the ship with the fish-pumping unit. The latter ship thus carries out only unloading operations, fulfilling no transport /219 functions, which operationally and technically is the most advisable arrangement, since with such an organization of the

---

* Translator's note. No suitable equivalent is available for the term alaman. The context, however, suggests that it designates a type of fishing gear.

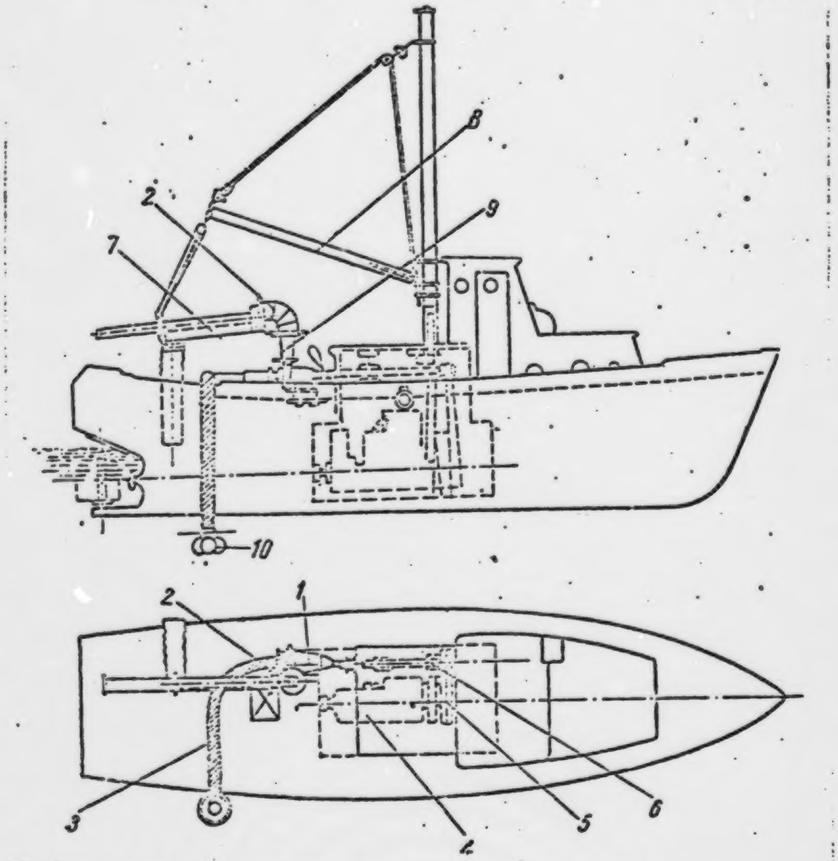


Figure 96 - A ship fish-pumping unit:

1 - RB-100 fish pump; 2 - rotatable elbow; 3 - intake hose; 4 - engine; 5 - belt drive; 6 transmission; 7 - water separator trough ; 8 - boom; 9 - diffuser; 10 - return valve with protective grating.

work, one ship, equipped with a fish-pumping unit, can service several purse seines.

Centrifugal fish-pumping units on ships have been widely used for unloading fish from purse seines during the catching of anchovy in Kerch Strait (see Fig. 96).

In 1949 a similar ship fish-pumping unit was used in the Baltic Sea for unloading herring from trap nets; the /220 results were favourable.

[For work such as that mentioned above] an RB-100 centrifugal fish pump (or a larger model depending upon the fish that are being transshipped) is mounted on a wooden frame directly on the deck of a motor ship (usually on the deck of a motor boat) or in the structure over the engine compartment.

The fish pump is driven by the ship's engine through a transmission, which can be of both the chain and the belt type. The rubber intake hose, which is 100 mm in diameter, consists of two sections.

Depending upon the method of priming the fish pump and the intake hose, a reverse valve is installed either on the end of the intake hose, or on the branch delivery pipe of the fish pump. At the end of the intake hose is installed a metal framework for preventing the del'* of the seine from being drawn into the hose. In order to reduce the speed of the mixture of fish and water emerging from the vertical branch delivery pipe of the fish pump, an expanding conical diffuser, which ensures that the discharge speed of the mixture of fish and water is no more than 1 m/sec, is fastened on this branch pipe. A hood or elbow that can rotate in a horizontal plane is installed at the upper end of the diffuser for directing the mixture emerging from the diffuser and for securing the trough of the water separator. The water separator trough is about three metres long and consists of a perforated and a solid part; each part is equal approximately to half the length of the trough itself. Under the perforated part is installed a metal bottom pan. The water that is separated from the fish is removed through a canvas hose over the side of the ship. The water separator trough is suspended at its free end by a compound pulley and a cable from a boom attached to the ship's mast. When the ship is under way, the water separator trough is stowed on the stern. During transshipment operations, it is mounted above the transport ship at a slope that ensures the separation of the mixture and the conveying of the fish into the hold. The unit is handled by three members of the ship's crew.

---

* Translator's note. See Translator's note, P 345.

The work sequence of a ship fish-pumping unit. The purse seine is cast and closed either with machinery from a specially equipped motor ship or manually from launches with oars.

After closing has been completed, the seine is lifted slightly, i.e., its del* is taken up over the ship's side manually by fishermen. At this time, a ship with a fish-pumping unit approaches the seine from the side opposite the fishermen and takes aboard the upper part of the seine. The intake hose of the fish pump is then lowered into the purse seine, and, if necessary, the fish pump is primed with water. At the same time, a water-separator trough is mounted over the hold of the transport ship, which is moored on the opposite /221 side of the motor boat ship carrying the fish-pumping unit. After the fish pump is started, transshipment of the fish begins from the seine into the hold of the cargo ship.

As the fish are pumped out of the purse seine, the latter is removed from the water, the del' being lifted up only on the deck of the ship making the catch.

After the fish have been discharged, the motor boat carrying the fish-pumping unit approaches another closed seine for unloading fish from it. After its hold has been filled with fish, the transport vessel is towed by a motor vessel specially designed for this purpose and is taken away to the wharves for unloading, while an empty transport ship approaches the side of the motor vessel with the fish-pumping unit.

---

*Translator's note. See Translator's note, P 345 .

The practice of using such ship fish-pumping units for unloading purse seines has demonstrated that they are highly efficient and that their use is most advisable. The heavy and laborious operation of unloading a seine by hand has been completely mechanized, the work has been made much easier and the number of workers involved has been reduced.

Above all, the acceleration of unloading has increased the time spent by the fishermen directly on fishing; it has increased the utilization of fishing gear per unit of time and has improved the efficiency and yield of such equipment.

Where the concentration of the mixture is normal, (not less than 1:4), almost all of the fish that are transshipped enter the hold of the transport vessel live, while in the water separator trough the fish are completely separated from the water. When the concentration of the mixture is at a normal level, the discharge of a unit with an RB-100 fish pump while it is unloading fish from alamans reaches 30 tons per hour.

The approach of a vessel with a fish-pumping unit to a closed* purse seine presents no difficulties. Work on unloading fish from a purse seine is quite feasible where the wind and waves are as high as 4 on the intensity scale, i.e., as long as it is possible to catch fish.

---

* Translator's note. The word "closed" is here a rendition of the Russian skol'tsovannyi, which suggests the drawing together of a series of rings by a rope or cable passed through them.

Such floating fish-pumping units can also be used for unloading trap nets.

All operations on unloading fish from trap nets can be divided into the following stages:

1) the approach of a transport ship together with a motor vesse carrying a fish-pumping unit to the pot of a trap net and the anchoring of the ships for unloading;

2) preliminary operations for unloading the fish from the trap net;

3) the process of unloading the fish and simultaneously hauling in the net webbing of the seine (sometimes termed cutting off the seine) in order to drive the fish towards the pot of the seine;

4) the withdrawal of both ships from the trap net.

The greatest difficulty arises from the first operation - /222 approaching the seine and placing the ships in operating position. Trap nets are often installed in places with a strong current and considerable heaving of waves. In order to retain the net, it is fastened with metal guys and gunders*, forming, around the trap net a zone that is dangerous for a ship approaching the net. A ship carried away by the wind and the current, if it approaches incorrectly, can get its rudder or its screw entangled in the guys. On the other hand, under the action of the wind and the current it can lean on the trap net and seriously damage it.

---

*Translator's note. No suitable equivalent is available for the term gunder. The context, however, suggests a type of brace or stay.

Therefore the approach of a ship to a trap net requires of the vessel operator and the entire crew efficient work, a knowledge of the design of a given trap net, and allowance for local conditions, wind, waves, etc.

The experience of using ship fish-pumping units in Kerch Strait has shown that these difficulties are fully surmountable, and that the high efficiency gained from the use of fish pumps for unloading fish from trap nets requires that they be introduced as rapidly as possible in other water basins.

8. Experiments in the Electric Catching of Fish Using a Fish Pump

Attemps to catch fish with the aid of electricity have been made in various countries at different times since the middle of the last century. Most of these attemps have been based on the fact that a fish placed in the electrical field of a direct current in water, at certain values of the strength and voltage of the current, turns its head towards the anode and itself attemps to move from the cathode to the anode (electrotaxis).

In order to achieve this condition for different species of fish at different compositions and water temperatures, the voltage and the current strength must be altered. Lower voltages frighten away the fish, while higher voltages stun them and cause them to lose independent movement. No regular movement of the fish is observed in either case. This may explain contradictory published data on the effect of a direct electric current on fish.

Numerous experiments on the use of this phenomenon in commercial fisheries have hitherto met with no success either in the USSR or abroad. Only the capacity of an alternating current for frightening away fish has to some extent been applied commercially. By the sending of an alternating current through the intake gratings of hydroelectric power plants, the turbines can be protected by [the resultant] electric fences from the entry of fish, and the fish themselves can be directed into fishways.

The main difficulty in the use of the guiding action of electricity on the movement of fish is the short duration of its effect, measured in seconds. For example, for salmon /223 species the duration of such a condition in a fish ranges from 9 to 13 seconds. After this, the fish becoming charged, as it were, with the electric current, moves off to the side, paying no attention to the continuing action of the current. The second difficulty is the great irregularity in the distribution of an electrical field between two electrodes of opposite charge.

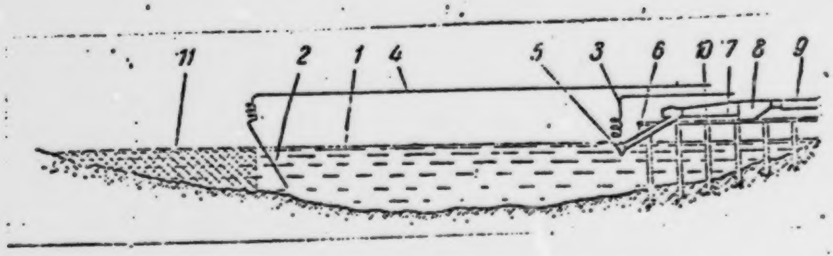


Figure 97 - Diagram of the catching of fish with a fish pump in a river using electric and net fences:

1 - river; 2 - electrode; 3 - wire generator anode; 4- wire of generator cathode; 5 - metal spout of hose; 6 - intake hose of fish pump; 7 - fish pump; 8 - circulation tank; 9 - hydraulic conveyer; 10 - wharf; 11 - additional net fence.

The first difficulty reduced to naught results of attemps by experimenters to concentrate the fish in some area by the action of an electric current and then to catch them using nets and drag seines. The operations with the net fishing gear and the process of fishing itself were measured in tens of minutes, and the duration of the effect of the current, in seconds. With such a time discrepancy, the fish succeeded in regaining consciousness and moving away, while the net caught either empty space or a catch that differed in no way from the usual catch. The conclusions of the experimenters regarding the inapplicability of direct current to the catching of fish become understandable. Owing to the irregular distribution of the electrical field between the two electrodes of opposite charge (the second difficulty), the dimensions of the effectively operating electrical field are small.

On the face of it, it may seem that there is essentially no difference between unloading fish with a fish pump from a ship's hold and taking them directly from a river. In both cases there is a mixture of fish and water that the pump can draw in and convey to the receiving platform, but in the river the fish are alive and have a natural instinct that urges them to go against the current. During the operation of the fish pump, water is drawn into the receiving hose; a local current in the direction of the hose forms in the water. Fish passing by, feeling the current in the direction of the hose, will immediately move a safe distance away from it and will not be drawn into the hose. In order to deceive the fish's instinct for self-preservation, the guiding action of a direct current must be used. The action of the current is far stronger than the natural instinct of the fish. If the metal spout of the intake pipe of the fish pump is connected to the positive conductor of the direct current, i.e., if it is made an anode (see Fig. 97), and one /224
or several metal sheets placed at some distance from the anode are used as a cathode, an electrical field will be formed between the two. If certain electrical values are given to this field, electrotaxis may be achieved in all fish passing through it.

Under the effect of the current, a fish approaches the intake spout of the hose, and here, against its will, it enters the active intake zone of the fish pump. The intake action of the fish pump is momentary; therefore the fish, not managing to regain consciousness, is drawn into the hose and thrown out onto the platform. With the appearance of fishing gear that acts instantly, - the fish pump - it has become possible to use an electric field in catching fish.

In 1947 N.F. Chernigin produced an experimental installation for catching /fish/[1] by electricity. A water-jet fish pump was mounted on a cargo ship and located on the shore of a river opposite a fish-receiving wharf. This was done for the purpose of testing the conditions under which electric fishing would be successful where the fish were moving freely in the river. Near the wharf, incoming and outgoing cargo vessels and launches frightened the fish away and changed the direction of their movement.

The fish that were caught were sent together with water from the fish pump to the wharf through a system of rubber and steel pipes laid along the bottom of the river. A cable, laid on the river bottom at the same time as the pipes, supplied current from a local power station to the motor of the fish pump and to a high-voltage unit located on the same ship on which the pump was mounted. The rubber intake hose of the fish pump was lowered directly into the river; on the hose was put a metal spout connected to the positive conducting wire of the high-voltage unit. On the spout was a grating of wooden strips arranged in the form of rays around the spout (in order best to direct the fish attracted by the current).

Two iron sheets were mounted on floats at a certain distance from the spout; to the sheets were led wires that connected them to the negative pole of the high-voltage unit.

There was an observation tower on the ship; from a height of 4 to 5 metres there was a good view as far as 3 metres below the surface; it could be seen how the fish moved and how they altered their movement under the effect of the electric current.

When the hose had been lowered into the water, and the fish pump was operating, but the current was not turned on, not one fish entered the hose, since all felt the flow towards the spout. As soon as the current from the high-voltage unit was switched on, the fish located between the electrodes and the spout sharply altered their direction of movement and rushed towards the spout of the hose. When they approached /225 the spout, the fish were drawn into the hose and conveyed to the fish receiving platform through a system of pipes. The fish evidently recovered consciousness in the pipes, since when they emerged, they were already opposing the current of the water carrying them out of the pipe and the collecting tank. Neither external nor internal injuries were observed among the fish. The fish caught by the new method differed sharply in their fresh appearance and cleanliness from fish, lying alongside on the wharf, that had been caught and unloaded from kungasy by the usual methods.

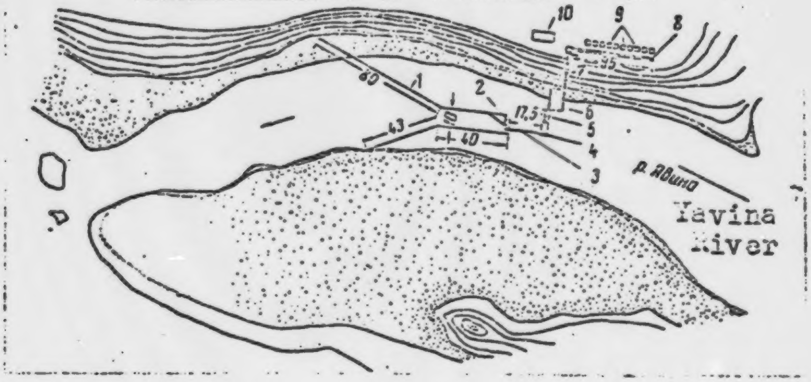


Figure 98 - Plan of a unit for electric fishing on the Yavina River:

1 - pile and lattice partition for electric fishing 2 - small service bridge; 3 - fish conduit; 4 - NCh-3 fish pump; 5 - bin; 6 - fish filleting wharf; 7 - scraper conveyer; 8 - belt conveyer; 9 - pickling tubs; 10 - electric power station.

In 1947 a fish pump using electricity (electric fishing) in 11 hours of tests caught 25 centners /2,500 kg7 of pink salmon and sockeye from the river.

In 1953 609 centners /60,900 kg7 of salmon were caught at an experimental installation on the Ozernaya River (Kamchatka) with electric fishing and a fish pump. This proved that it was possible to obtain commercial catches using this system. In 1954 this unit was transferred to the Yavina River for tests on catching salmon with electricity under industrial conditions (see Fig. 98).

The experimental unit for electric fishing that was set up in 1953 on the Ozernaya River, was theoretically repeated on the Yavina River in 1954. A partition of piles and lattices concentrated, in a narrow, ten-metre passage, the fish that were going upstream to spawn. The partition consisted of shaped piles (see Fig. 99) driven for a depth of up to 1 metre into the bottom at distances of 3 to 5 metres from each other. Between the piles were inserted lattices of steel rods 6 to 8 mm in diameter arranged vertically at a distance of 35 mm from each other. To each fourth rod was brought one of the AC conducting wires with voltages ranging from 12 to 50 volts.

Where the AC voltage fed to the partition was /226 correctly chosen, the fish did not pass through the partition. When there was no electric current, the salmon, particularly char and pink salmon, passed through the partition in the same way as was observed on the Ozernaya River in 1953.

The partition was placed at a distance of 500 metres from the mouth of the river in order to catch fish that had just entered from the sea; in such fish the signs of breeding colour arising from a lengthy stay in fresh water were still largely undeveloped.

The corridor of the partition ended in a small service bridge, from which a supervisor during the work controlled the voltage of the electric current by sending agreed-upon signals to the power station.

This was the location of the remote DC switch for the electrodes and the standard AC switch for the partition in the event of emergency shutdown.

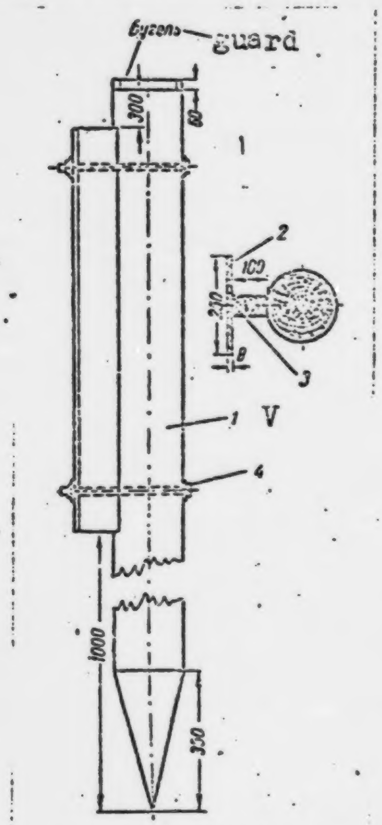

Бугель
guard
300
80
1
2
100
230
8
3
1
V
4
1000
350

Figure 99 - Shaped pile of partition for electric fishing:

1- wooden pile 18 to 25 cm in diameter; 2- metal cover plate;
3- wooden beam; 4- bolt.

Under the service bridge, half-way to the bottom of the river, was the spout (a bell mouth) of the fish intake conduit, which served as an anode.

The bell mouth of the fish pump (see Fig. 100) consisted of a metal funnel covered almost completely with several layers of an asphalt lacuer. The only non-insulated area remaining was a narrow strip 140 mm wide within the bell mouth, which served as the anode proper, being in electrical contact with the positive terminal of the generator through a wire and a bolt.

In order to avoid mechanical injury to the insulating layer when the bell mouth was shifted, two layers of rope were wound around it from above. The bell mouth was tightly secured in a flexible rubber hose with the aid of a clamp drawn together by two bolts 16 mm in diameter.

A brass bolt 7 mm in diameter with a semicircular head having a groove for a screwdriver was inserted in an opening drilled after the hose and the bell mouth were assembled. The bare end of a wire was placed under the /227 washer of the bolt and clamped in place with a nut. After this, the upper ends of the bolt and the wire were sealed with hot pitch and were covered from above with two layers of lacuer so that the connection was securely insulated from the water.

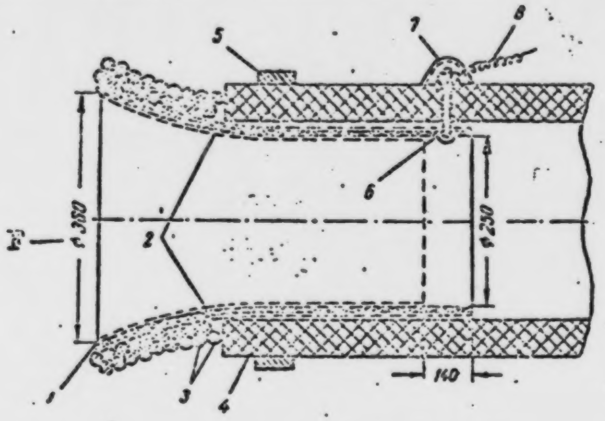


Figure 100- Diagram of the bell mouth of a fish intake conduit for electric fishing:

1- metal bell mouth; 2- layer of asphalt lacquer; 3- two layers of rope; 4- rubberized intake hose; 5- band;
6- bolt of electrical contact; 7- bolt insulation;
8- anode wire of generator.

The wire was of a special high-voltage grade in rubber insulation and was rated for a voltage of up to 10,000 volts. The insulating properties of the current-carrying wire were designed to withstand lengthy immersion in water.

Cathodes in the form of two sheets of galvanized iron fastened on wooden poles were placed along the sides of the guide gratings at distances of up to 3 metres from the bell mouth. The distance between the electrodes, and their mutual arrangement in relation to the bell mouth, were regulated by the supervisor. The iron sheets of the cathodes touched the bottom of the river.

The fish intake conduit was connected to an NCh-3 fish pump installed on a platform.

Owing to the conditions of the area in which the assembly was carried out, it was not necessary to convey the fish that had been caught to a considerable height or distance. Therefore, the second stage - a fish pump of type RB-250 - was not installed.

The fish pump was located on a special platform and conveyed a mixture of fish and water through a closed water separator into a fish-receiving bin. By means of a water separator, part of the water was sent back to the centrifugal pump of the NCh-3 water-jet unit, which helped to increase its [the centrifugal pump's] efficiency. /228

Without the return of the water from the water separator, the pump created a pressure of 0.9 to 0.95 atmospheres, owing to which a vacuum of 150 to 170 mm was created in the mixing chamber of the NCh-3. When the pump operated with the water that was returned from the water separator, the pressure of the operating water rose to 1.1 to 1.15 atmospheres, while the vacuum in the NCh-3 mixing chamber amounted to 200 to 210 mm. The NCh-3 fish pump was set in motion by a 380-volt, 30-kw AC electric motor operating at 1,450 rpm, and was handled by one man. During the period of work there was required only a periodic check of the correct operation of the self-lubricating bearings, the centrifugal pump, and the electric motor.

The operation of a unit for electric fishing on the Yavina River in 1954 took place in the same sequence as the operation of an experimental unit for electric fishing on the Ozernaya River in 1953. The natural tendency of salmon to pass from the sea into a river and to move upstream to spawn was used as a means to compel the fish to gather from considerable distances and to enter the electric field.

When they had entered the mouth of the river and found the partition in their path, the fish began to seek an opening. The arrangement of the wings of the partition at an angle of 30° to the direction of movement of the fish, helped the latter to find this opening.

Entering the opening, the fish continued to move against the current and entered the electrical field formed by the electrodes and the bell mouth. Under the effect of the field of direct current, the fish, in the stage of electrotaxis, headed for the bell mouth of the fish pump with abrupt movements.

Trapped by the current at the bell mouth of the fish pump, the fish entered the intake pipe and in 15 to 20 seconds were conveyed to a measuring bin and, further, to a fish filleting [cutting] platform. The catch of the electric fishing unit on the Yavina River in 1954 was 961 centners [96,100 kg].

Research by the Mechanization Laboratory of the Kamchatka Division of TINRO has proven that the catching of fish with a fish pump and an electric current has no adverse effect on either the quality or the outward appearance of fish.

Studies on electric fishing on the Ozernaya and Yavina Rivers have determined the type of assembly of a river unit for catching fish using the suction of a fish pump and the guiding action of electric currents on the movement of the fish.

Experiments in using electric current for catching fish have also been carried out in a number of foreign countries. Extensive research has proven that a direct pulsating current with a low number of pulsations (3 to 15 per second) represents the most effective means from the viewpoint of action on the fish and the most economical with regard to power consumption. One of the latest experimental units has been mounted on the American ship *John N. Cobb*. In this unit, the combined equipment /229 used for catching the fish consists of underwater illumination, which attracts the fish, electrical equipment, which creates a field of force and stuns the fish, and a fish pump, which draws in the stunned fish.

The electrical equipment for stunning the fish attracted by the light consists of two electrodes, one positive and the other negative. The positive electrode consists of four carbon plates each measuring 56 x 156 x 6 mm set in a wooden cone put with its narrow end on the end of the intake hose. The negative electrode consists of a close-woven wire net (20 wires per 25 mm of net fabric) in the shape of a disc 90 cm in diameter. The disc is fastened on a wooden base.

The anode and the cathode are rigidly fastened together with a wooden framework of rods [each] measuring 50 x 100 mm. The distance between the anode and the cathode may be altered within the limits of 0 to 3 metres.

A 1,000-watt lamp is suspended from a horizontal rod of the framework between the anode and the cathode and can be moved along the rod, which makes it possible to arrange the lamp in the most advantageous fishing position with respect to the electrodes and the intake hose. The lamp is equipped with an automatic rheostat for regulating the intensity of the underwater light.

The electrodes of the field of force are supplied with power from a DC dynamo. A 30-kw, 220-volt, three-phase ship's generator is used for supplying power to the dynamo. With the aid of an electronic pulser included in the circuit, the assembly passes to the electrodes a pulsating direct current with a pulse frequency of 3 to 13 at 110 to 150 volts.

The fish that are attracted by the light and stunned by the electric current are caught with a centrifugal fish pump. The fish pass through an intake hose and a fish discharge pipe into a vat measuring 2.4 x 3.9 metres, mounted on the ship's stern.

The installation was tested in the sea at depths of 1.5 to 4.5 m.

The catch mainly consisted of small herring measuring 7.5 to 8 cm. Larger herring (15 to 18 cm) gathered together at the light, but kept beyond the limits of the field of force and almost failed to enter the fish pump.

The action of the installation that we have described was as follows. After the fish pump hose with the electrodes and the lamp was lowered into the water, the underwater light was switched on. When a school of fish appeared in the illuminated zone, the electrodes and the fish pump were turned on. Under the action of the electric current, the fish located at a distance of about 60 cm from the anode, rushed towards it. When they came within about 5 cm of the anode, they were stunned by the current and were drawn into the intake hose. Where the weather was favourable, and the fish were in sufficient quantity, they entered the pump in a solid, unbroken stream.

The best results were achieved during simultaneous work /230 with the light and a field of force. Without the light, the fish did not gather in the zone of the electrical field; when the light was switched on, but the field of force was switched off, many fish escaped.

Attempts to use periodically intensifying or diminishing light yielded no favourable results. Herring were caught most successfully when the lamp shone continually and at full strength.

Catches were best when the source of light was located 40 cm directly in front of the anode and 45 cm above its centre.

As observations showed, the hours before sunrise (four to six o'clock in the morning) are the best time for the operation of the fish-pumping assembly.

Under optimum conditions, the discharge of the fish-pumping unit reached 1,178 fish per minute, but in other cases, where either the weather or the current was unfavourable, the discharge fell to zero.

A serious drawback of the fish-pumping unit that we have described was the fact that up to 60% of the fish that were pumped were seriously injured, which must evidently be attributed to the imperfection of the American fish pump, since Soviet fish pumps, working under similar conditions (see section 9 of this chapter), cause virtually no injury to fish. The injury to the fish cannot be attributed to the effect of the electric current, since according to the data of N.F. Chernigin, fish are not injured by electric current.

Plans have been made to carry out experimental studies on electric fishing at sea in the very near future. The achievements of Soviet and foreign technology will be used in the course of these studies.

9. Catching Fish with an Electric Light and a Fish-Pumping Unit

In recent years the catching of fish with underwater electric illumination has begun to be widely applied. This type of fishing has been used with particular success for catching southern sprat in the Caspian Basin, where centrifugal fish-pumping units mounted on board ship were for the first time successfully used as catching and unloading devices.

At the present time, where southern sprat are caught with light the main fishing gear is a dip net * which is shaped like a net cone. A lamp in an airtight mounting is fastened in the centre of the plane of the ring forming the intake. Electric current is fed to the lamp through a flexible wire from a special generator.

Sprat are caught with two conical nets lowered alternately /231 into the water to the necessary depth from both sides of a ship. The nets are also raised alternately with a winch from a boom extended beyond the side of the ship.

---

* _Translator's note_. A suggested rendition of the Russian _podkhvat_.

The technique and the commercial equipping of fishing for Caspian sprat with the use of underwater illumination are being continuously improved, and catches of sprat have been increasing from year to year. During this time, an efficient design has been developed for the conical net, and its capacity for catching fish has been studied. In addition, special electric lamps for underwater illumination, and reliable water-tight fittings for them, have been created. Substantial technical and organizational drawbacks inherent in fishing for sprat with conical nets have not, however, been eliminated. Among these drawbacks are the considerable laboriousness of such a method of fishing; the high percentage of juveniles taken along with fish of commercial value, and the warming of the sprat when they are raised from the lower cold layers to the upper warm layers of the water, etc.

The above drawbacks have made it necessary to look for other methods of catching sprat at night, methods fundamentally altering the nature and conditions of the work of the fishermen.

The first attempt to catch sprat with the aid of a fish pump was made in 1948 by N.S. Fershtut. This work was continued from 1949 to 1951 by an experimental base of the Volgo-Caspian Trust. At that time, however, these experiments were not successful, since the catch in one hour of continuous operation of the fish pump did not exceed 60 kg, and the quantity of injured sprat reached 40%.

It became evident that this problem could not be treated without a broad and detailed study of the behaviour of sprat in an illuminated area and in the operating zone of fishing gear depending on variable factors in the environment and physiological condition of the fish.

In addition, it was necessary to establish the operating conditions of the fish-pumping unit and the power and arrangement of the electric lamps in the catching device, etc.

In 1952, a group of officials of the Caspian Branch of VNIRO (I.V. Nikiforov, A.F. Laksutkin, A. Kh. Pateev and A.P. Shishov) developed a technique for catching sprat with a fish pump.

Special underwater observations were carried out in order to investigate the behaviour of sprat in the sphere of action of intake currents of water.

It was established that three zones form around the intake diffuser during the operation of a fish pump: a zone of active intake, a critical zone, and a zone that is safe for fish (see Fig. 101).

After the fish pump had been started, the sprat located in the sphere of active intake were instantly drawn in. In view of the considerable force of the intake, the fish could not resist the current and were carried away by it irrespective of the positions of their bodies in relation to the direction of the current (head against or with the current, across the current, /232 etc.).

In the critical zone some of the sprat (up to 70%), which were unable to resist the current, were drawn in by the fish pump; the remaining fish (up to 30%) actively opposed the current and swam away. The critical zone was located above the sphere of active intake. The fish which, at the moment when the fish pump was turned on, had their heads against the current, found it easiest to emerge from the critical zone.

The sprat were observed to behave as we have described in the critical zone only when they were lightly concentrated. When they were heavily concentrated, they were unable to emerge from the critical zone, since new, approaching schools of fish pressed them towards the zone of active intake.

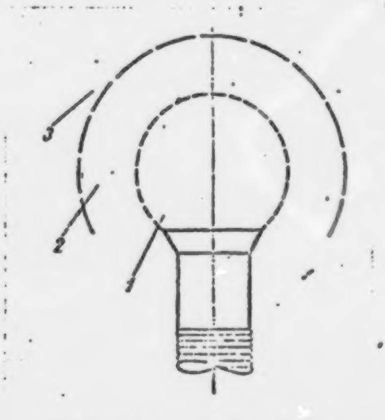


Figure 101 - Distribution of zones at the branch intake pipe of a fish pump:

1 - zone of active intake; 2 - critical zone; 3 - safe zone.

Underwater observations have shown that in order to obtain heavy catches with a fish pump at any concentration and distribution of sprat in the illuminated zone, an attempt must be made to increase the zone of active intake. The intake sphere of an RB-100 fish pump with a discharge of 90 m3/hour has been inadequate.

Tests have also been made of various types and shapes of spouts on the intake hose of a fish pump in order to establish their best shape and design.

A number of spouts have been tested - those with an upright and an inverted truncated cone; disc, hemispherical and cylindrical spouts and finally, a spout in the form of a chamber with round, slitlike openings.

The spouts were tested in various positions in the water (with the intake opening directed upwards, downwards and to the side).

Of all the spouts tested, that which caught the most fish was cylindrical, with its intake opening directed upwards and with two electric lamps mounted for underwater illumination along both sides.

In order to enable the catching device (see Fig. 102) to be raised and lowered together with the intake hose to the required depth, a frame was fastened to the spout; to the upper part of the frame was attached a steel cable leading to a ship's winch.

In 1954, the medium refrigerator fishing trawler [SRT] Toros [see Fig. 103] was equipped for the multiphase mechanization /233 of the catching and processing of sprat. This move was the result of work carried out by officials of the Caspian Branch of VNIRO on the effective use of a centrifugal fish pump for catching sprat with the aid of underwater illumination, and by officials of the Astrakhan Division of VNIRO in the field of mechanizing the processing of sprat by refrigeration directly on board ship.

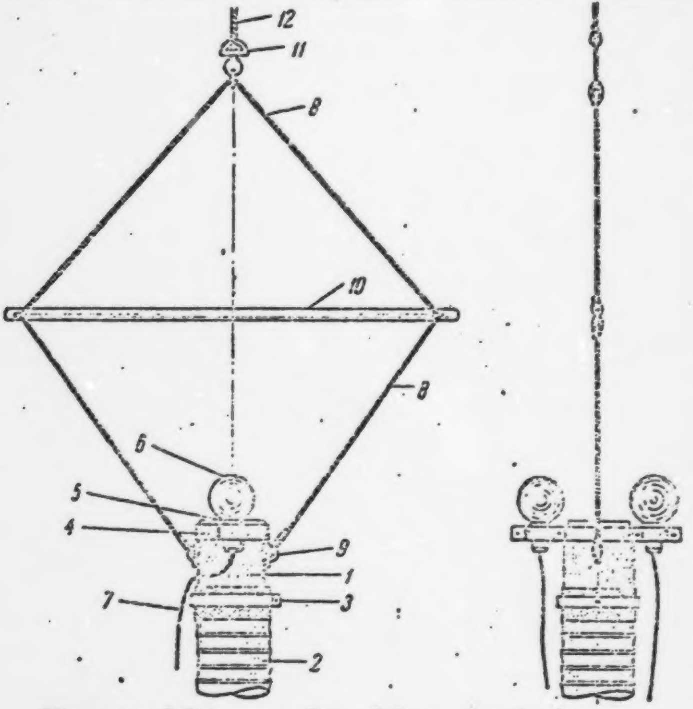


Figure 102 - Catching device:

1 - spout; 2- hose; 3 - clamp; 4 - clamp; 5 - socket;
6 - electric lamp; 7 - RMSh wire; 8 - sling; 9 - loop;
10 - strip; 11 - swivel; 12 - cable.

Commercial tests of the multiple mechanization on board the medium fishing trawler Toros demonstrated its definite advantages as compared with existing methods of catching and processing sprat. The introduction of multiple mechanization on a number of ships has therefore now begun, which will promote the wide use of this effective method of utilizing hydraulic engineering in catching and processing fish.

A description of the multiple mechanization of the catching and processing of sprat is given in Chapter XI. /234

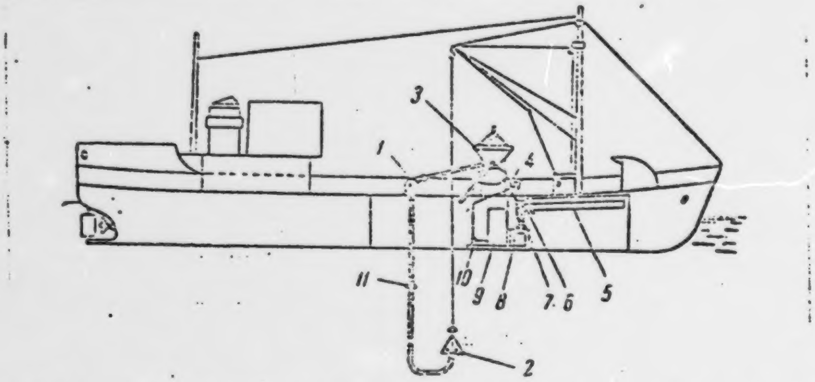


Figure 103 - Diagram of the arrangement of equipment on board ship:

1 - RB-150 fish pump; 2 - catching device; 3 - water separator; 4 - receiving bin; 5 - cooler; 6 - reticulate water separator-conveyer; 7 - packing bin; 8 - packing table; 9 - refrigeration unit*; 10 - centrifugal pump; 11 - return valve.

---

* Translator's note. The term "refrigeration unit" is used here and elsewhere as an equivalent of the Russian kholodogenerator, which means literally "cold generator".

10. Net Frames

Because of the considerable inconvenience involved in transporting fish in kungasy and unloading the latter by hauling them up on the shore, Okhotsk and Sakhalin fishermen, with the appearance of fish pumps in 1947 and 1948, began to transport herring from trap nets live in net bags. The net bag (a vaku**) was suspended from the sides of the kungas in such a way that under the kungas there was formed a space covered on all sides by the net and the bottom of the kungas itself. Herring were passed from the heart of the trap net into this space. The kungas, together with the net bag and the fish, was conveyed to the fish-receiving platform, where the herring were unloaded with a fish pump and the kungas was again sent with the net bag to catch fish.

The use of net bags for conveying live herring has a number of advantages: the unloading of fish from the heart of a trap net is facilitated, since it is replaced by the shifting of the fish from the heart into the net bag; the unloading of fish on shore is made easier by the fact that in the net bag there is a ready-made mixture of fish and water, which the fish pump has only to pump to shore; fishing industry enterprises receive live herring on shore, which has a favourable effect on the quality of the product. The lifting *** of such a bag during unloading by the fish pump presents considerable difficulties. When approaching wharves with shallow depths, the net bag occasionally brushes against the bottom and bursts open, and the fish swim back into the sea. Control over the condition of the fish in /235 the bag and over the condition of the bag itself is very difficult.

** Translator's note. No precise English equivalent available.

***Translator's note. The term "lifting" is used here and elsewhere as an equivalent of the Russian podsushka, which means literally "drying a little".

In 1949 on the initiative of fishermen of the west coast of the Sea of Okhotsk the use was begun of net frames for transporting fish live. The net frames retained all the advantages of the net bags. The main advantages of the net frames are high capacity, low cost and simplicity of installation. A kungas is not required for a net frame. Owing to the simplicity of their installation, net frames are made by the fishing industry enterprises themselves, which explains the absence of standardization in their dimensions and shape. Wooden rods measuring 20 x 20 cm are connected into a rectangle that usually measures 4 x 6 metres. For rigidity, the frame is braced with cross rods.

The forward part of the frame is occasionally given the shape of a ship's prow. It cannot be considered, however, that such a shape has definitely proven to be advisable. The rectangular frame is towed angle first.

Within the frame is suspended a net bag from one to two metres deep. Ordinarily the frame has a depth no greater than half the depth at low tide in the unloading area, since allowance is made for the fact that submerged anchors, which can tear the bottom of the frame during towing, are frequently found in the shore zone.

Six to eight empty iron barrels are fastened along the sides of the frame in order to create buoyancy. In Kamchatka in recent years welded steel vessels with cone-shaped ends have begun to be used in place of barrels. These vessels, as practice has shown, are more durable, and when the net frame is towed through the sea they have less resistance than barrels.

The frame is enclosed from above with net webbing in order to prevent the fish from being washed out during swells. In a frame of this kind, anchored in a roadstead, live fish keep well for four to five days even when the waves are at force 5 on the intensity scale.

The dimensions of the frame determine its capacity. Depending, however, upon the species of fish, the state of transportation, the type of towing vessel and the rapidity of unloading at the shore, the quantity of fish conveyed in the frame can vary within wide limits.

In conveying live fish in a net frame, it is important not to allow a large quantity of fish to lie in layers (to grow stiff). A net frame with fish lying in layers is very difficult to unload, since lifting it requires great effort.

In Kamchatka, up to 300 centners (30,000 kg) of live herring or salmon is conveyed at one time in frames measuring 4 x 6 x 2 metres for a distance not exceeding 3 km.

The loading of the frame is reduced if it is assumed that the frame may stand at the shore for more than 6 hours prior to unloading.

Frames measuring 4 x 6 x 1 m are more appropriate for salmon on the west coast of Kamchatka because of the shallow depths at the places for setting up the roadstead fish pumps with which fish are unloaded from /236 net frames.

Among the drawbacks of net frames are their high resistance when they are moved in water, and the difficulty of lifting them.

In Kamchatka, when fish are transported for a distance exceeding 3 km, kungasy rather than frames are used.

The proposal of Fisherman Vazhenin of the Chief Directorate of the Fishing Industry in the Amur Basin /Glavamurrybprom/ is of interest with regard to facilitating the lifting of a net frame.

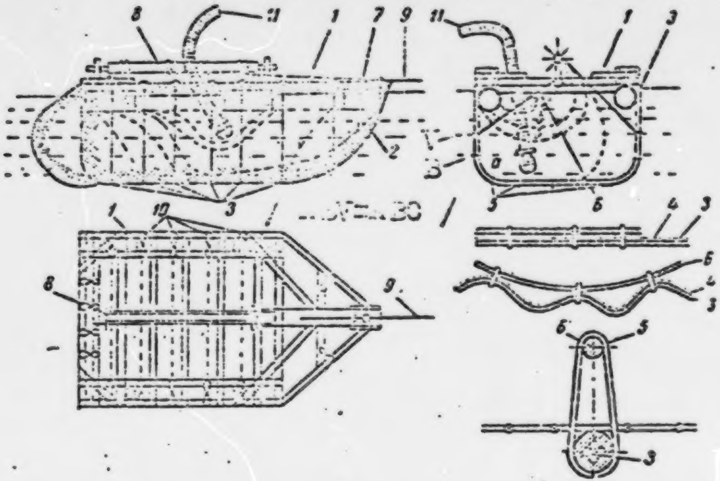


Figure 104 - Diagram of the mechanization of the lifting of a net bag on a frame:

1 - framework of net frame; 2 - net bag; 3 - support cables
4 - net webbing; 5 - stirrups of support cable; 6 - tie cable;
7 - barrels for giving buoyancy to frame;
8 - windlass for taking up tie cables;
9 - cable for towing frame; 10 - pins for fastening support cables;
11 - intake hose of fish pump.

Steel rings are fastened along the width of the net webbing of the frame at intervals of 1 to 1.2 metres between the rows. Steel cables 6 to 8 mm in diameter are passed through the rings. Each cable is fastened tightly at one end to the frame. When the frame is lifted, the other end of each cable is wound on the shaft of a 0.5-ton hand winch (see Fig. 104)

Lifting of the net bag begins with the cable that is farthest from the winch. The remaining cables are taken up by the winch in consecutive order. In the process, the net bag is gradually reduced in volume in the direction of the snore piece of the fish pump and, consequently, the fish in the net bag are driven towards the snore piece. Lifting of the net bag by this method requires less physical effort on the part of the workers than manual lifting.

On Sakhalin, frames of a different design are used for /237 lifting and unloading net bags. Sakhalin fishermen fasten the frames in a cantilever arrangement to the wharves of fish plants. The suspended end of the frame is hung on cable guys from masts installed on the wharves. In some cases, such frames are fastened to the wharves on hinges, and their guys are run through pulleys to winches, with which the frames are raised and lowered. A net bag is conveyed from the fishing area to the fish plant on a _kungas_, which is brought up under a lowered frame. The bag is then transferred to the frame, the _kungas_ is withdrawn from the bag and moved aside, and the bag is drawn up on a block and tackle higher towards the frame. When the frame is raised, the net bag is lifted.

It must be noted that this system has a number of substantial drawbacks. In particular, the withdrawal of the _kungas_ from the bag suspended from the frame requires great efforts on the part of the crew of fishermen, while lifting using a hinged frame is ineffective.

A new modification of cantilever frames on wharves is now being widely introduced on Sakhalin (see Fig. 105).

A metal frame with an overhanging length of about 3 metres is fastened in a cantilever arrangement on a wharf where a fish pump has been installed, and its free end is suspended from two masts with booms. Along the edges of the frame are rollers for lifting the net bag. Between the tops of the masts is extended a cable from which the intake hose of the fish pump is suspended on a pulley. A hand winch for raising and lowering the hose is mounted on the wharf.

One of the rollers mounted on the frame is set in motion by hand with the aid of a ratchet wheel. The other roller is driven from a 4.5-kw, 1,000-rpm electric motor through a reducing gear with a gear ratio _i_ = 1:40 and a belt drive with a gear ratio _i_ = 1:3. Thus the roller revolves at about 8 rpm.

Each roller is cigar-shaped, about 200 mm in diameter, has a corrugated surface and is set on a shaft 40 to 50 mm in diameter and about 2,800 mm long. The drive roller is connected by the main toothed clutch to another shaft, on which are set two cable drums; the second shaft is connected by a flexible clutch directly to the shaft of the reducing gear.

The net bag containing the fish is shifted from the transport kungas to the frame; the kungas is withdrawn from the bag, the suspensions being slackened and the top line of the bag submerged, and the front ends of the bag are drawn up using the cables and cable drums of the drive roller and are wound on both rollers. The rollers are set in motion and the net is lifted.

With such a system, the operation of lifting net bags is immensely facilitated where fish are unloaded from the bags with fish pumps and a minimum amount of time is spent on preparing the bag for the pumping out of the fish. The lifting of a net bag with the aid of rollers is highly efficient.

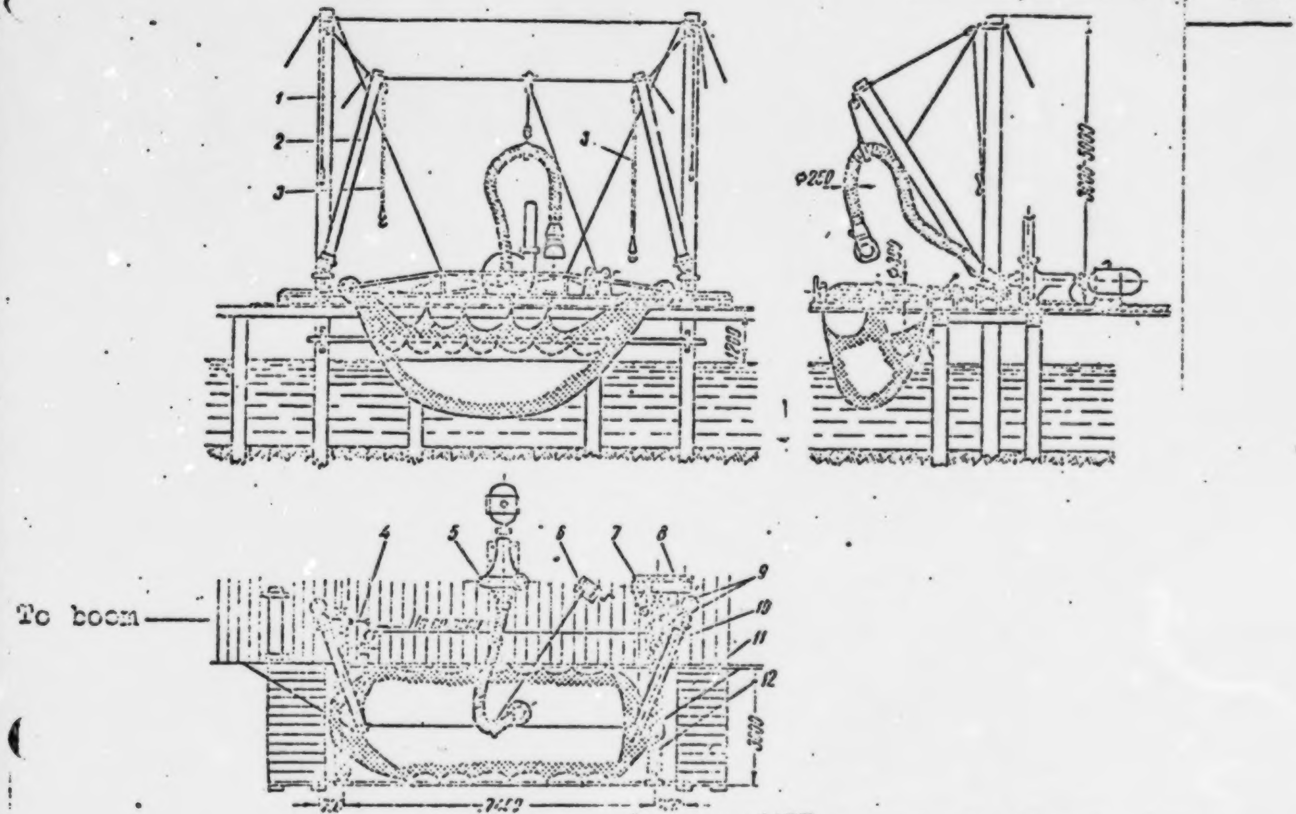


Figure 105 - Diagram of cantilever frame of Sakhalin type for suspending and lifting/drying net bags:

1 - mast; 2 - boom; 3 - block and tackle for raising del'* of bag when it is suspended from the frame and set for the rollers; 4 - hand roller; 5 - RB-200 fish pump; 6 - hand winch for raising intake hose of fish pump; 7 - electric motor (N = 4.5 kw, n = 1,000 rpm); 8 - reducing gear (i = 1:40); 9 - drum for cables of booms; 10 - main toothed clutch of drive roller; 11 - board flooring on frame; 12 - drive roller.

---

permits lifting to be carried out evenly and at the proper time, which has a favourable effect on the operating conditions of the fish pump and on its performance.

In the Far East the increased use of net frames has occurred at the same time as that of fish pumps, without which the unloading of fish from net frames would be virtually impossible.

---

* Translator's note. See Translator's note, p 345.

11. The Use of Pumps for Placing Trap Nets in the Northern Caspian

One of the most laborious operations in placing trap nets is the driving into the bottom of the piles on which the nets are mounted. In the shallow regions of the northern Caspian, where such a method of placing trap nets is widely used, piles are driven in from ships by hand with a rammer. In order to mechanize this laborious and heavy work, N.S. Fershtut has proposed that the bottom be washed away under the pile at the place where it is to be installed. For this purpose he has equipped a small ship (a podchalok*) with an M-600 motor-operated pump (the weight of the pump is 69 kg, and the power of the engine is 12 hp), an intake hose 3" in diameter and a water-jet pipe 3/4" in diameter, connected to the motor-operated pump with a hose.

The pile is set up on the bottom; the water-jet pipe is lowered alongside; the intake hose is let down into the water; the motor-operated pump is turned on, and the soil begins to be washed away from under the pile, which sinks into the bottom under its own weight. After the pile has been lowered to the required depth, the water-jet pipe is removed. In three to five minutes the pile is firmly secured in the bottom by the drifting action of the water. The time taken to install the pile is one minute; here, output per man-hour increases 12 to 15 times.

---

* Translator's note. A podchalok is a small boat that is not raised on board a ship, but is rather towed behind it. No suitable English equivalent is available.

Chapter X

HYDRAULIC MECHANIZATION IN THE PROCESSING OF FISH /240

1. The Fundamentals of Applying Hydraulic Mechanization to the Processing of Fish

The application of hydraulic mechanization to the processing of fish is the next step after the mechanization of the unloading and conveying of raw fish. The development and introduction of hydraulic methods of processing fish permit the creation of multiple projects for the hydraulic mechanization of fish-processing factories. This yields a number of advantages, since it ensures the fastest processing of the fish, which in turn permits, apart from a reduction in labour input, the manufacture of a product of the highest quality.

In 1950 hydraulic mechanization in fish processing was developed mainly for salting fish, principally herring. Here the basis of the hydraulic mechanization was that a liquid medium (brine, in particular) was used mainly as a chemical reagent and as a carrier of chemical preservatives, one of which was NaCl. The sphere of application of hydraulic mechanization to the processing of fish has now considerably widened owing to the inclusion of other fish besides herring in hydraulically mechanized pickling operations, and the use not only of the chemical properties of the liquid medium, but also, in more varied ways, of its physical state (density) and its thermodynamic properties (thermal capacity and temperature). Hence hydraulic mechanization is beginning to be used in the grading of fish according to specific gravity, saltiness, and the presence of burst fish, and in the refrigerative processing of fish.

The use of the dynamic properties of the liquid medium in applying hydraulic mechanization to the processing of fish is a question that stands apart. The application of hydraulic fish conduits and fish pumps is based on the theory of the use of the dynamic properties of a liquid medium; the loosening, with streams of brine, of caked salted fish also pertains to the field of the dynamic effect of a liquid medium on fish that is being processed. The use of a hydrodynamic effect for the purpose of creating tools for removing scales from fish and for cutting caked salt has unfortunately not progressed beyond the building of experimental models that have been tested with encouraging, but far from exhaustive, results.

The application of hydraulic mechanization to the processing /241 of fish has introduced substantial changes into the technology (and occasionally leads to the appearance of a new technology) of preparing a fish product. Thus, for example, a completely new technology is taking shape at fish pickling plants, where the hydraulic mechanization of pickling has been applied with the use of circulating brine; a new technology of catching and preserving during transport is appearing in connection with the introduction of hydraulic mechanization into the processing of Caspian sprat at the fishing area.

When Caspian sprat are taken, in the process of their being delivered to the plant an immense quantity of burst fish forms; this makes the sprat unsuitable for canning or preserving /by non-canning methods/ and causes them to be sent for crude pickling, which is unprofitable and does not satisfy the requirements of the consumers.

The introduction of hydraulic engineering methods into the preparation of Caspian sprat permits the latter to be used for the manufacture of high-quality canned goods and /non-canned/ preserves.

As experience has shown, the introduction of hydraulic engineering into processing considerably improves the economy of production.

Thus the basis for the application of hydraulic engineering in the processing of fish is represented by the use of the chemical, physical, thermodynamic and hydrodynamic properties of a liquid agent in systems of hydraulic mechanization in which this agent interacts with the fish, and the possibility of creating a new technology of fish processing with an improvement in the quality of the manufactured product, a general reduction in labour input, and an increase in the efficiency with which fish products are manufactured.

2. Hydraulic Mechanization in the Thermal Processing of Fish

By the hydraulic mechanization of the thermal processing of fish should be understood chiefly the freezing and chilling of fish in cold brine. Thermal processing with the use of the elements of hydraulic mechanization also includes browning fish in oil baths and pickling it in heated brines.

Wet Freezing of Fish

The manufacture of chilled and frozen fish products is continually increasing, and chilled and frozen fish are beginning to represent the greater part of the total amount of fish products, both in absolute quantities and proportionately. This has also been a reason for the application of hydraulic mechanization to this branch of fish processing.

There exist several methods of freezing fish. One of these is wet freezing, in which the fish are immersed in cold brine of temperature of -15° and lower and are frozen through until the temperature in their bodies falls below -8°; this method also permits freezing to be /242 included in a system of hydraulic mechanization.

The process of freezing in such a bath lasts three to four hours and is accompanied by the salting down of the surface, as a result of which the commercial qualities of the fish deteriorate somewhat. Aside from the change in the palatability inherent in freshly frozen fish, during freezing in brine the surface of the fish darkens somewhat, a certain quantity of salt in the upper layers of the fish makes its surface hydrophilic, the fish virtually does not lend itself to glazing, and during storage in a refrigerator is subject to surface oxidation. All of this applies for the most part to fat fish (herring) and to a lesser degree to thin fish (cod).

The process of freezing in brine (wet freezing) is usually contrasted with dry freezing on racks in refrigerator chambers or in fast-freeze refrigerators, in which streams of cold air circulate around the fish. Dry freezing gives frozen fish faultless quality (if a certain drying is not considered), but on the other hand it continues for days and is far less efficient than wet freezing. Moreover, the distributing of the fish on shelves and their removal after freezing represent extremely laborious processes which have so far not been mechanized.

A discussion held in 1950 on whether one or the other freezing method should chiefly be used, led to the acceptance of dry freezing as the preferred method.

In the freezing of fish caught by the trawler fleet, however, in particular cod, the wet method of freezing is still used, and the quantity of fish frozen in this way has been continually increasing.

Fish are hydraulically frozen in vats (see Fig. 106) with a circulating concentrated brine of a temperature of about -15°. The fish are scattered into the vat. Above the vat is mounted an apron conveyer whose lower arm immerses the fish in the cold brine and slowly moves it towards the other end of the vat, where it is fed out frozen onto a packing conveyer.

Thus the process of freezing itself is here completely mechanized and is carried out on the principle of an assembly line. At the same time, labour input is 1.5 to 2 times less than in dry freezing.

The conveyer has a speed variator and interchangeable drive sprockets permitting the speed of movement of the fish in the brine to be changed and allowing the time that fish remain in the brine to be altered within the limits of 0.5 to 4 hours, since the duration of freezing of different fish is not the same and depends upon their species and linear dimensions, the condition of their surface, and their fatness.

Wet freezing vats with conveyers have been used at the Murmansk /243 Fisheries Combine, where they are termed conveyer freezing tanks.

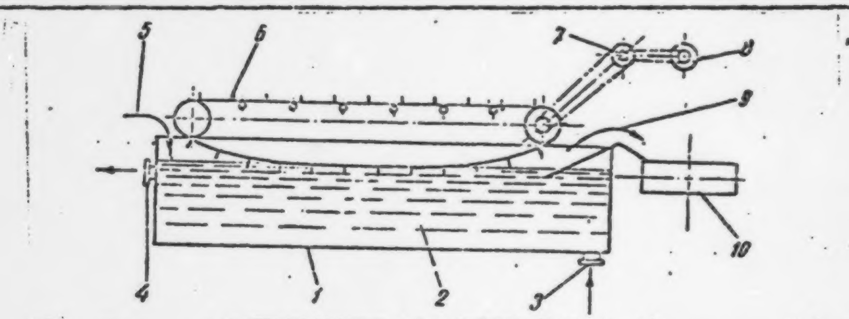


Figure 106 - Line diagram of a freezer conveyer tank at the Murmansk Fisheries Combine:

1 - vat; 2 - brine of a temperature of -15 to -17°;
3 - branch pipe for delivering brine; 4 - branch pipe for discharging brine; 5 - loading fish; 6 - immersing conveyer;
7 - speed variator with interchangeable sprockets;
8 - electric motor with interchangeable sprocket;
9 - discharge of refrigerated fish; 10 - packing conveyer.

Refrigerating Fish in a Liquid Medium

In 1955 conveyer freezer tanks were used for the mass refrigeration of fish down to a temperature of 0°. The capacity of the freezing tanks to vary the duration of immersion of fish in the brine was used, and the tanks were readjusted to a duration of 30 to 50 minutes. During this time the fish were not salted even in the surface layers.

In 1955 at the Murmansk Fisheries Combine, the use of freezing conveyer tanks for refrigerating fish permitted the production of about 300,000 centners [30,000,000 kg] of refrigerated fish in 1.5 months.

The use of hydraulic methods for freezing and refrigerating fish has still not produced a multiple system for the hydraulic mechanization of a fish-processing enterprise. At the Murmansk Fisheries Combine, where freezer conveyer tanks are used with extremely high efficiency, all conveying of fish from the ship to the processing plant, as well as its grading prior to processing, is performed without the use of hydraulic mechanization. There is, however, every reason to introduce a multiple system of hydraulic mechanization at this, the largest enterprise [of its kind] in the Soviet Union. Since the route for conveying fish from the wharves through the Combine is very long and has many branches, both water and brine hydraulic conveyers could considerably simplify and facilitate the conveying of fish at this enterprise. This could be successfully combined with the use of freezing and refrigerating conveyer tanks as one of the main means of processing fish at the Combine.

It is to be hoped that the idea of using multiple hydraulic /244 mechanization under the conditions of the Murmansk Fisheries Combine, as put forward by certain officials (M. I. Sazykin, I.T. Sakharov and others), will be realized within the next few years with good results from the viewpoints of production and economics.

A multiple system of hydraulic mechanization of the primary processing of fish by refrigerating (in applying the catching of sprat with electric light and fish pumps to hydraulic mechanization) has been developed by the Astrakhan Fish-Processing Division of VNIRO (N.S. Volkova and others) for ships catching sprat commercially by electric light in the Caspian and is described in Chapter XI.

Sprat are caught in the Caspian mainly in the summer, when the temperature of the upper layers of the water is 18° and higher, and the atmospheric temperature is 30° and more. Raw sprat is not a durable material. In high temperatures autolytic and other processes take place very rapidly in the bodies of sprat; as a result, the tissues and integuments of the fish decompose, and specimens with burst abdomens appear which are not suitable for the manufacture of high-quality canned goods and [non-canned] preserves.

Sprat inhabit layers of water with a relatively low temperature (8°). When sprat are being caught with electric light and conical nets, they fill up the net almost instantly and, passing through layers of water of a higher temperature, rapidly absorb this temperature. This process is assisted by their large relative area. The sprat arrive on the deck of the ship in a warmed state, and all of the processes of decomposition take place very rapidly within them. Refrigeration with ice will not save such sprat from decomposition, since the biochemical processes that have begun in their bodies are difficult to stop at this stage; moreover, ice does not have a sufficient capacity for the rapid and comprehensive refrigeration of fish. As a result, sprat delivered in summer to fish-processing enterprises one to two days after they have been caught, in spite of the fact that they have been strewn with ice, include 50 to 70% and more burst fish.

In a system of hydraulic mechanization of the catching and primary processing of Caspian sprat they are drawn in by a fish pump from the water layer that they inhabit in a stream of water of a temperature that is characteristic of the sprat's environment; they arrive on the deck of the fishing vessel with no increase in temperature and immediately enter the refrigerating apparatus, where in five minutes they are chilled to a temperature of -1 or -2°, at which the processes leading to bursting of the abdomen in the fish are sharply reduced.

When sprat are chilled to 0°, after two days of storage at this temperature, the quantity of fish with burst abdomens reaches 39%. When the fish are chilled to -1° and stored at 0°, the quantity of specimens with burst abdomens reaches 39% only after four days, i.e., the processes of formation of such fish are doubly retarded. When the fish are chilled to -1° and stored at -1 and -2°, the quantity of fish with burst abdomens in four days does not exceed 25%.

Thus in this case hydraulic mechanization creates the optimum /245
conditions for obtaining a high-quality product.

The refrigerating apparatus (see Fig. 107) consists of a duct in the form of two pipes (connected on their surfaces) within which rotate shafts with blades. The shafts are made from pipes, and their ends are extended out through stuffing boxes and rest on bearings. A shaft rotates at 60 to 80 rpm. The blades mix the fish and the water, hastening the chilling of the fish. The fish move through the apparatus owing to the movement of a stream of water that enters from the receiving hopper with a pressure head of no more than 20 cm.

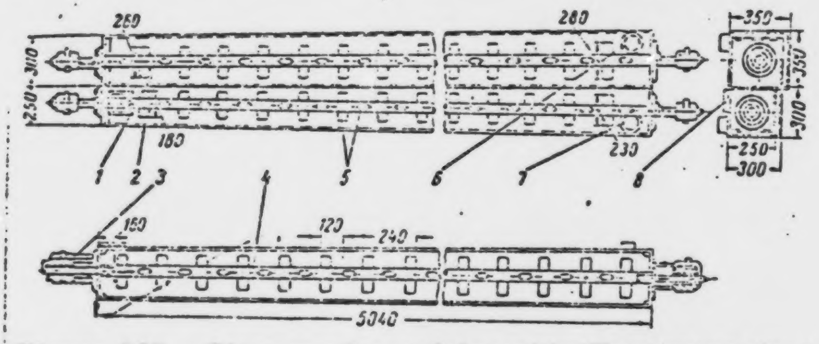


Figure 107 - Diagram of a refrigerating apparatus for Caspian sprat (designed by the Astrakhan Fish-Processing Division of VNIRO :

1 - upper pipe; 2 - lower pipe; 3 - bearing with stuffing box packing; 4 - tubular shaft; 5 - mixing blades; 6 - branch intake pipe; 7 - branch outlet pipe; 8 - inspection window.

The liquid refrigerating and conveying agent (salted sea water) circulates through the system as follows: refrigeration unit - centrifugal circulating pump - receiving hopper and cooling apparatus - water separator - sprinkling device of refrigeration unit - refrigeration unit. The refrigeration unit consists of two metal tanks with a total capacity of $3.5\ m^3$, into which a supply of ice is poured, while chilled water is fed from above by the circulating pump from the sprinkler. There is a salt concentrator (a closed tank) in the system for adding salt to the chilled water. The upper and lower parts of the tank are divided by a perforated metal sheet. Salt is poured into the upper compartment, while water from the circulating pump is fed through a branch pipe from below. This water, passing down through the salt, becomes saturated and enters the sprinkler, where it intermingles with the main body of the circulating water.

The output of the refrigerating apparatus has been in excess of 15 centners [1,500 kg] per hour for sprat; here the specific ice consumption has been 100 kg per centner [100 kg] of fish as against 250 kg /246 per centner of fish with the usual method of refrigerating fish directly by crushed ice. The power consumed in operating the refrigerating apparatus, the water separator-conveyer and the circulation pumps has not exceeded 7 to 8 kw.

The All-Union Scientific Research Institute of the Refrigerating Industry [VNIKhI] (S. I. Gakichko and V.D. Borodin) has developed another refrigerating apparatus for sprat (see Fig. 108), consisting of a centrifugal fish pump converted from a 2.5 NF pump and a conduit about 15 metres long, laid along the side of the ship. Passing through in a stream of pure sea water /with a high degree of turbulence, the fish are chilled to 0°. At the same time, VNIKhI assumes that further chilling and the associated salting of the water will have a harmful influence on the quality of the sprat and, especially, on the duration of its storage in a refrigerator.

[See page 443a]

Figure 108 - Line diagram of refrigerating apparatus for sprat (designed by the All-Union Scientific Research Institute of the Refrigerating Industry):

1 - 2.5 NF pump adapted for pumping sprat; 2 - 70 metre-long refrigerator conduit for sprat; 3 - receiving bin for sprat;
4 - discharge gate valve; 5 - vibration feeder; 6 - vibrator;
7 - pipe 100 mm in diameter for conveying sprat to cooler;
8 - receiving hopper of cooler; 9 - trough water separator;
10 - continuous-action filter for scale; 11 - trough for conveying refrigerated sprat to hold; 12 - centrifugal pump for circulating refrigerating water; 13 - service tank for the refrigerating water with level regulator;
14 - water cooler; 15 - overflow pipe.

The State Planning Institute for the Fishing Fleet /Giprorybflot/ has developed a design for a hydraulic cooler for sprat in which a Freon refrigeration unit is used as a source of cold. In this system, the water that refrigerates the sprat, is itself cooled in a contactless apparatus in which cold brine serves as the cold carrier; in order to prevent the walls of the apparatus from freezing, the speed at which the water /247 circulates in it has been increased. The system has been planned for mounting on a fishing ship of a new type for the Caspian Sea. A large series of these ships has been laid down at the Kirov Shipyard in Astrakhan; /each/ ship is equipped according to a system for the multiple hydraulic mechanization of the catching and primary processing of sprat with the use of fish pumps and hydraulic refrigerating equipment, the entire ship being refrigerated throughout.

The Cooling and Warming of Pickling Brines

In the practical operations of fish pickling plants it is frequently necessary to control the temperature conditions under which the fish are pickled.

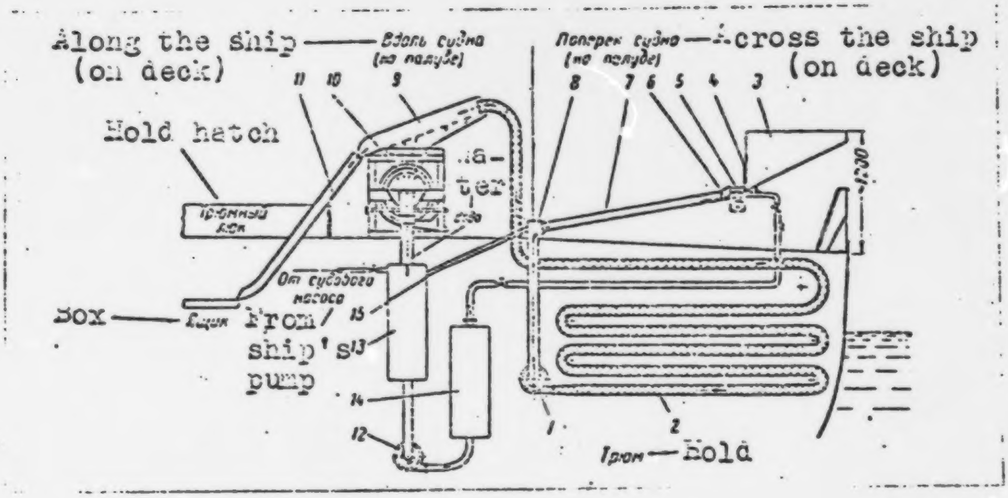

Along the ship (on deck) — Вдоль судна (по палубе)
Поперек судна (по палубе) — Across the ship (on deck)
Hold hatch
Трюмный люк
Water
вода
От судового насоса / From ship's pump
Box — Ящик
Трюм — Hold
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure 108 - [For details see page 443.]

In most cases, the temperature at which the brine flows must be reduced; there are, however, instances in which it is necessary to raise the temperature of the brine artificially.

Thus when fish are pickled in summer, when the atmospheric temperature is 20 to 25°, the temperature in the pickling vessel rises to such an extent that the microbiological processes in the bodies of the fish take place faster than the process of salting down. This causes a putrid odour in the gills, and other signs pointing to the spoiling of the fish. A method is known of refrigerating fish with ice in the process of pickling: here ice is added to fish that have been pickled in a vat. In this method, however, the fish are not uniformly refrigerated to the prescribed temperature, and, moreover, if the pickler lacks sufficient skill, the surface of the fish can freeze and on it can form an incrustation of ice that will impede the penetration of salt into the tissue of the fish, which also leads to spoilage.

As the practice of Sakhalin herring-pickling plants has shown, the best method of refrigerating herring in the process of pickling is to refrigerate and circulate brine. In this case, a small refrigeration unit, which chills the brine to the required temperature by a contactless method, is included in the brine circulating system.

At Sakhalin fish plants a refrigeration unit with a 4AU-15 compressor, with which the temperature of the brine in a shed with a capacity of up to 5,000 centners /500,000 kg/ is maintained within the entirely satisfactory range of 4 to 8° during the summer, has been adopted for this purpose.

Under the conditions of remote regions of Siberia that are isolated from railways and where the frosts are very severe, the pickling of fish in autumn is complicated by the fact that the low temperature of the brine in the vats sharply retards salting down, and at the same time all of the fish must be shipped out by water routes before the navigation season closes. The heating of pickling areas and of the vats themselves is virtually impossible.

K. A. Bashkirov, at the Ust'-Port plant of the Krasnoyarsk State Fisheries Trust, conducted an experiment on heating and circulating brine during pickling in low atmospheric temperatures.

[Please ignore space below; text is continued on next page.]

The brine was heated in a boiler to 23°, was pumped into a supply tank and was periodically passed through the pickling vat from the bottom up. The brine flowing out of the vat was sent for heating, filtration and reconcentration. /2

Seven tons of whitefish [*Coregonus muksun*] (a fairly large, fat fish) were loaded into the vat. The temperature of the fish's bodies at the moment when they were loaded in was 3.5°, and after warm brine was passed [through the vat] the temperature of the fish rose to 10°. Under these conditions, the salting down of the fish to 6% saltiness (light pickling) continued for three days.

The salting down of a control batch without the addition of warm brine and at a temperature of about 3° took place four times as slowly, and a salinity of 6% was achieved only after 12 days.

3. The Hydraulic Mechanization of Fish-Grading Operations

The specific gravity of a fish is a parameter that characterizes its condition. It has been established that changes in the specific gravity of a fish functionally reflect changes in its age, fatness and saltiness.

To the extent that cell fluids whose specific gravity is close to one, and fat, whose specific gravity is less than one, are discharged from fish during the formation in the latter of bursting conditions, the influence of the heavier parts of the fish's organisms - tissue and skeleton - grows, and the specific gravity [of the fish] increases. Thus in a number of cases, specific gravity serves as a characteristic parameter for separating whole fish from those that have burst or have suffered mechanical injury.

In some cases, specific gravity characterizes a species of fish.

According to the findings of A. P. Chernogortsev, the specific gravity of salted fish (bream and roach) changes considerably depending upon saltiness (see Fig. 109). By loading

---

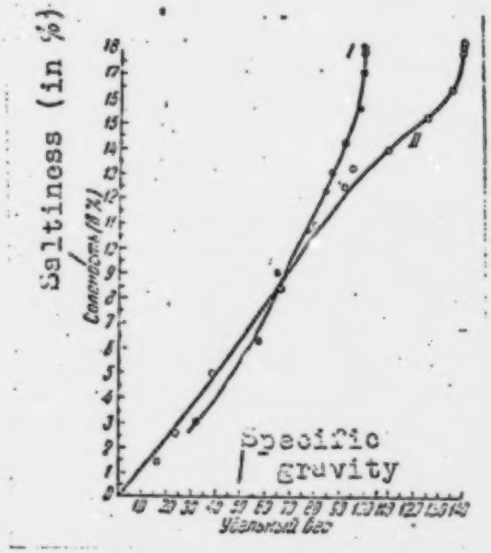


Figure 109 - The change in the specific gravity of fish in relation to saltiness:

I - specific gravity of bream; II - specific gravity of roach.

---

salted bream and salted roach into brine with a specific gravity of 1.07, success was obtained in sorting out lightly salted fish (with a saltiness of up to 10 to 12%) from medium and heavily salted fish (with a saltiness in excess of 12 to 14%).

N. N. Niyazova and M. P. Menkovich graded Caspian sprat in brines according to their specific gravity for the purpose of sorting out fish that had burst from those that had suffered no mechanical injury. In this operation, whole sprat rose to /249 the surface, while those that had burst, sank.

Where the saltiness of the sprat was 9 to 12%, the ratio of the mixture of fish and brine was 1:2 to 1:3, and the strength of the sorting brine was from 5 to 16° Baumé, they [Niyazova and Menkovich] succeeded in sorting out burst and whole sprat with the best results at 7, 10, and 12° Baumé; at the same time, about 10 to 15% of the whole sprat sank together with the burst fish. It was noted that in sorting by hand under industrial conditions some of the whole sprat were also sorted out together with the burst fish, while a certain quantity of burst fish passed into the small sprat that had been sorted out.

When the sprat were graded in brine into adults and juveniles, it was established that after 24 hours of pickling the saltiness of the adult sprat was 10.9%, and that of the juveniles, 13.3%. These fish were sorted out in brine with a strength of 8 to 10° Baumé; of the sprat that floated, 31.3 to 39% were adults, while 25 to 17% were juveniles. Of the sprat that sank to the bottom, 2 to 4.7% were adults, while 41.7 to 39.3% were juveniles ([this] percentage is taken from the overall quantity of sprat).

A. P. Makashev and N. T. Berezin established that the specific gravity of tiulka [Clupeonella d. delicatula] is from 1.01 to 1.04, while that of ruff, a harmful fish taken along with tiulka, is 0.97 to 1.00.

Upon the separation of mixtures with a content of 10 to 60% ruff and, correspondingly, 90 to 40% tiulka, in brine with a specific gravity of 1.01 to 1.015, 1 to 7% of the ruff remained in the part of the mixture that sank, while from 13.3 to 33% of the ruff rose to the surface, i.e., when the fish were passed through brine, the admixture of ruff among the tiulka decreased.

Thus by classifying fish according to their specific gravity in brine, we can sort out fish of equal saltiness and the same species and can separate fish that have no injury from those that have. Since the above features for the most part serve as keys in establishing the grades of fish products and raw fish, grading by specific gravity leads ultimately to classification by grades of fish, which is very important for the profitableness of the work of an enterprise.

The idea of the hydraulic mechanization of the grading of fish by specific gravity appeared as early as 1936 to 1938, when the State Designing Institute for the Fishing Industry* designed a machine for sorting salt cod by their specific gravity (see Fig. 110). A decisive unit in this system was an automatic salt concentrator, which maintained a constant specific gravity in the brine in the grading vat.

---

* Translator's note. A suggested expansion of the abbreviation Giproryca.

A regulator of this type can be provided with a float including an electric contact that sets in motion a system of slide valves by means of which a stream of brine from the vat, forced through a filter by a pump, is directed through salt. Hereupon the salinity of the brine flowing from the vat, is increased, as is the specific gravity of the brine, if its concentration falls below normal.

Several proposals have now been made with regard to the /250
hydromechanical grading of small fish in brine, combined with the pickling of this fish in circulating brine.

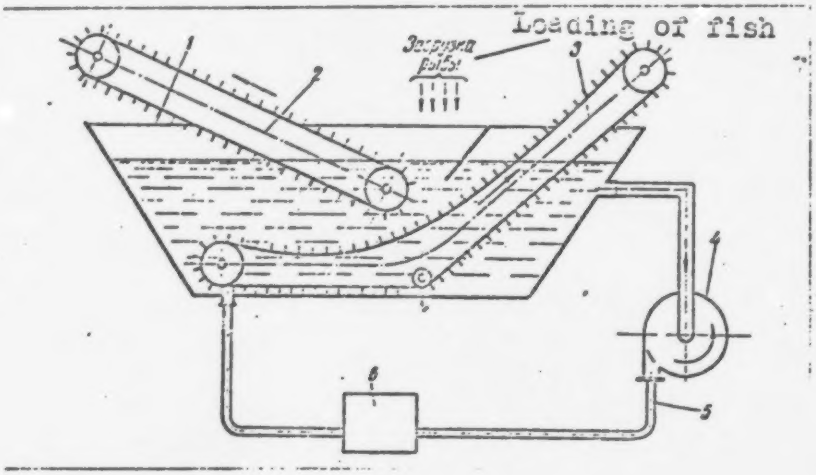


Figure 110 - Line diagram of machine for grading salt cod according to specific gravity:

1 - grading vat; 2 - conveyer for removing less salted fish; 3 - conveyer for removing more salted fish; 4 - pump; 5 - circulation conduit; 6 - automatic salt concentrator.

The fact that in the last five years a fairly large amount of experimental material has accumulated on the hydraulically mechanized grading of fish, gives reason to assume that this method will receive practical application in the near future.

4. The Hydraulic Mechanization of the Pickling of Fish

At fish processing enterprises one of the most laborious and physically difficult operations is the pickling of fish. When small fish (anchovy, tiulka / Clupeonella d. delicatula /, etc) are pickled, all of the fish must be mixed with salt in such a way that each fish will be covered by it. When medium-sized fish (herring, roach and bream) are pickled in vats, bins, etc, the fish must be either rolled in the salt or carefully laid out in level rows and sprinkled with salt in such a way that there is a layer of salt between each row (layer) of fish. Large fish (salmon, chum, etc) are salted individually, each fish being carefully rubbed with salt; in some cases, the salt is introduced into the abdominal cavity, the gills, etc.

According to the findings of I. P. Levanidov, in order to salt Caspian herring by hand in one vat, under the normal conditions of catching fish and conveying it for pickling, the following personnel are required: two salters, two rakers and one man for hauling salt to the bins. Given this work force, the pickling of one bin, holding 12.5 tons of fish, consumes approximately 2.5 hours. Thus the work input in this case /251 is one man-hour per ton of fish, which is fairly high, considering both the laboriousness of the process and its physical strain. During peak inflows of fish on days when the catches are especially heavy, when the labour force is insufficient, the output per man-hour of the salters increases by approximately 25% owing to the increase in the intensity of the work and the physical overexertion of the workers, and also owing to less careful pickling of the fish.

An extremely laborious operation is the bringing of salt on hand-barrows to the pickling area: of a crew of 26 men, 15 are occupied in carrying salt, 3 in pickling, 6 in raking and 2 in pushing the fish through the trough.

The amount of fish that is sent for pickling is large and will remain so, primarily on account of the pickling of herring, Baltic herring, anchovy, sprat, etc. Hence it becomes clear that with such a scale of labour input into the production of salted fish products, it is necessary to mechanize this form of fish processing.

The organization of commercial fishing on the shore of the Western Caspian (Dagestan and Azerbaidzhan) may be given as an example. Here, from March to May herring (Caspian shad) approach the shore in schools in which the concentration of fish reaches considerable proportions. The herring are caught with shore seines. The seines are generally hauled in by seine winches driven either by tractors or electricity. The catches are sometimes very large. During the fishing season, fishing itself is carried out during the entire period of the day for which there is daylight, i.e., for 17 to 20 hours. During this time from two to four casts are made at each fishing place. High winds are frequent during the fishing period. Moreover, in this region, even when the wind is comparatively light there is often a heavy swell. In the second half of the fishing season the atmospheric temperature is usually high (15 to 25°). Under these conditions, where the catches of fish are large, the following complications can arise. When the swell has risen, it will "drift" the seine with sand, and the entire catch will die. At the same time, it must be borne in mind that while there is fish in the bag of the seine, it is almost impossible to haul the bag onto the shore, since the seine can be broken by the swell. In calm, hot weather, and where the unloading of the seine has been delayed, a considerable portion of the fish in the seine die and spoil, resulting in a defective and low-grade product. When the seine is delayed, i.e., when it stands idle too long at the shore, the fishermen do not succeed in fulfilling the daily norm for casts and thus fail to catch a certain quantity of fish, which can be very considerable, since delays occur mainly during a period when fishing conditions are the most favourable.

The use of centrifugal fish pumps ensures the rapid /252 unloading of fish from the seine.

As a rule, pickling sheds in this region have a surplus pickling capacity, owing to which virtually any amount of fish may be received and accommodated. Difficulties, then, arise during the process of the manual pickling of fish.

The fishing situation that we have described represents the rule rather than the exception for the catching of spring spawning herring. In southern Sakhalin during the periods when the herring approach the shore to spawn, very large catches can be taken at one time, but if the weather is stormy it is extremely difficult to preserve the fish that have been caught until they are unloaded onto the shore. During the fishing season, fish pumps pump up to 120,000 centners /12,000,000 kg/ of fish daily to the shore; the overall amount of the catch, however, is limited by the brief periods of the fishing season and the amounts involved in daily unloading and treatment.

It is impossible to receive and pickle fish in the amount of 50 to 75 tons per hour with ordinary pickling methods, i.e., by hand. One highly efficient method is the pickling of fish in circulating brines.

A System of Pickling Fish in Circulating Brine

In this method, fish are sent in bulk in any quantity into the pickling vessel (tubs, bins, vats, etc), where they are salted not with dry salt, but rather with a concentrated (saturated) aqueous solution of salt (brine). The brine is pumped continuously through a supply tank into the pickling vessel. It passes through the layer of fish, transmits salt to the fish, absorbs the moisture that the fish give off during pickling, and thus lowers its own concentration. The brine is then sent to the salt concentrator, where its salt content is restored to full saturation, after which the brine is again pumped into the supply tank, from which it enters the pickling vessels. Thus in the pickling vessel - salt concentrator - supply tank system there is established a continuous circulation of brine, whence the name of this method of pickling, which represents a purely hydraulic method of mechanizing /the pickling7 process.

A general diagram of the pickling of fish in circulating brine is given in Figure 111.

In regions where the pickling capacity is limited, for example in the Azov-Black Sea area, where small fish (anchovy and tiulka) are caught and processed, the necessity arises for accelerating the physicochemical process of salting fish, in order that pickling vessels may be freed more quickly to receive fresh batches of fish. An additional requirement, therefore, is to increase the utilization of the pickling capacity per /253 unit of time. In this case, it is required that in the process of pickling fish in circulating brine not only must the process of receiving the fish be intensified, but also the process of fish-salting proper must be accelerated.

The idea of pickling fish in circulating brines arose as a result of a quest for high-speed methods of pickling. As early as the initial stage of experimentation in this field, however, researchers (T. M. Borisov and others) established the possibility of using this method of pickling as a means of hydraulically mechanizing one of the most difficult and laborious processes in the treating of fish.

Small and medium-sized fish (tiulka, anchovy, Caspian shad, Pacific herring and sardine) can be successfully salted in circulating brine and a high-quality product obtained. Attempts are being made to apply this method to the pickling of cod, run-of-the-mill species of fish, and salmon.

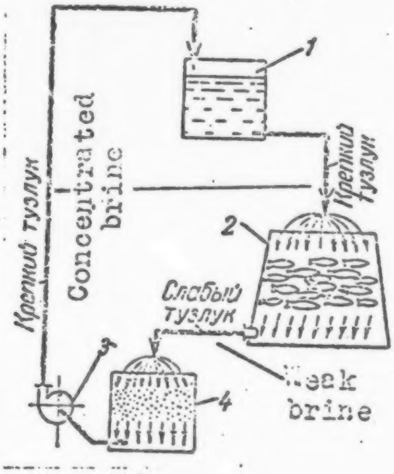


Figure 111 - General diagram of the pickling of fish in circulating brine:

1 - supply tank; 2 - pickling vat; 3 - pump; 4 - salt concentrator.

Canting*

A characteristic of the hydraulic mechanization of fish pickling is the considerable difference between the specific gravity of the fish that are being processed and that of the operating liquid - brine. The specific gravity of saturated brine $\gamma_T=1.2$, while the specific gravity of fish $\gamma_r = 1.04$.

The upper layers of fish, particularly at the beginning of the pickling process, are located above the level of brine in the vat and are not salted. If these fish are not forcibly immersed in the brine, they will spoil.

In order to immerse the fish in the brine, the area of the pickling vat is covered with a detachable sectional grating, frequently termed a pressure grating. Where circulating brines are being used, the pressure grating is placed on the fish when there is no circulation and when the level of the brine in the vat is low and the upper layers of the fish are located above the brine. The grating is secured at this level, after which brine is circulated in the tub; the level of brine in the tub rises above the level of the pressure grating, and all of the fish are immersed in the brine and pressed from below to the /254 pressure grating.

---

* Translator's note. The term "canting" is used in this translation as an equivalent of the Russian kantovka, meaning "to turn over or stir during processing. Among the meanings of the verb "to cant" supplied by Webster's Third New International Dictionary are "to tip over" and "to turn upside down".

The pressure of the fish on the pressure grating is expressed by the formula

$$P = V(\gamma_T - \gamma_P), \text{т} \qquad [82]$$

where: P is the stress on the grating, in tons;

V is the volume of the fish in the vat, in m^3;

γ_T is the specific gravity of the brine;

γ_r is the specific gravity of the fish.

In large tubs with a capacity of 13 to 15 tons, fresh fish that have recently been submerged in the brine, exert a pressure of 2,000 to 2,400 kg on the grating. Where the area of the vat is approximately 8 m^2, the specific pressure on the fish will be 0.03 kg/cm^2. At such a pressure, the upper fish are compressed to such an extent that the circulating brine does not penetrate into the spaces between the fish, and the process of salting the latter stops. Continually intensifying signs of spoilage of the fish begin at once to appear: reddening of the gill covers and the eyes and subsequently a putrid odour.

The first to spoil is not the uppermost layer of fish, which is in contact with the grating and is washed by the brine through the openings in the grating, but rather the subsurface layer, which is situated at a depth of 5 to 10 cm from the grating

In order that the brine may once more begin to enter the spaces between the fish, the latter must be freed from pressure and stirred in the brine. This operation is called canting.

Canting is carried out by various methods, depending upon whose use the setup of a pickling method changes.

The simplest method is canting by hand using a raker. The latter consists of a wooden pole with a cross piece fastened on the end. Stirring fish in a vat with a raker is a very difficult process.

Not less than 30 minutes are required in order to cant four tons of herring in a vat by hand. In the course of manual canting, the canted fish are mechanically injured by the raker.

The results of experiments, as well as the practice of brine pickling on Sakhalin from 1951 to 1953, have shown that in the process of pickling, fish must be canted two or three times, the first canting being performed a day after the fish have been loaded into the vat. I. P. Levanidov, on the basis of his observations, considers that there should be no less than three cantings for Sakhalin spring spawning herring. The present carrying out of canting during the pickling of fish in circulating brine makes it possible to obtain a ready-made finished product that is much more evenly salted than in ordinary pickling with dry salt. Thus in experiments with the pickling of Sakhalin spawning herring in 1950 results were obtained that are given /255 in Table 22.

Table 22

Data from Experiments in Salting Sakhalin Herring

Vat No.	Pickling method	Least saltiness of fish flesh, in %	Greatest saltiness of fish flesh, in %	Range of saltiness, in %
1	Pickling in circulating brine.........	7,90	8,05	0,15
2	Same............	8,05	8.94	1,89
3	Same............	6.87	8,91	2,04
Control vats	Pickling with dry salt in the usual way...........	6,00	11,00	5,00

In experiments with Pacific sardine in vats where the fish were canted, the variations in saltiness were less than 2%, and in vats where there was no canting, the variations were more than 3%.

The less variation in the saltiness of fish from one and the same vat, the greater the yield of a superior grade product from this vat. Actually, the practice of pickling fish in circulating brine has shown that the yield of a superior grade product in some cases exceeds 90%, which is considerably greater than the yield of superior grade product from pickling by the usual method.

Canting by hand is a laborious and extremely difficult operation. Hence attempts have been made to avoid or modify the canting process.

Thus A. V. Terent'ev and N. I. Sukrutov, in experiments with the pickling of Caspian herring in circulating brine (Pervomaiskii Fish Plant, 1945) replaced canting with the pumping of brine from the vat in order that the fish might sink to the bottom and not float. At the same time, the fish in the vat were sprinkled with streams of brine from above, and the mass of fish was sprayed with streams of brine from a unique monitor - a section of pipe 1" in diameter put on a hose delivering brine with a pressure of about 1 atmosphere. Spraying was carried out in this way every six hours for a whole day /[24 hours/]. With this system, a satisfactory uniformity was achieved in the salting of the herring, whose saltiness on the seventh day of pickling varied within the range of 12.0 to 14.2%. The spraying of the mass of fish, however, proved to be a fairly difficult operation, and where it was frequently repeated it was more laborious than ordinary canting. This method, therefore, was not applied.

In 1949 B. K. Tido and N. T. Berezin carried out experiments at the Yuzhno-Nevel'skii Fisheries Combine on replacing the process of canting with the pumping of brine from the vat until the latter was empty. Under this arrangement, thought the experimenters, the pressures should be redistributed in the fish that had sunk to the bottom, as a result of which some fish should shift relative to others and, after the circulation of the brine was renewed, fish that had previously been pressed and had not come into contact with the brine, would now be washed by it. The experiments, however, did not yield favourable results. The herring in the upper layers were not salted. When the experiments were repeated in 1950, I. P. Levanidov and A. V. Terent'ev also obtained negative results; after six days of pickling, the saltiness of the fish in the upper layers was 2.3%, whereas in the lower layers it was 7.6%, and in the middle layers, 3.4%. /256

Levanidov carried out experiments on pickling herring in circulating brine in vats that were divided by vertical partitions into compartments about 50 cm wide, and in vats divided by horizontal gratings at a distance of 50 cm from each other. The setting up of the experiments with vertical partitions was based on the premise that the movement of brine along a rectilinear wall would take place more freely than in the winding channels within the mass of fish; it was assumed that from the vertical walls the brine would penetrate into the compressed layers from the side. This assumption was not confirmed by the experiments.

Experiments with horizontal gratings have not yet been completed, but preliminary data give no reason to hope that canting may be done away with.

Together with experiments on replacing canting, other experiments have been carried out on mechanizing this process. All efforts at mechanizing the canting process have been aimed at transferring fish in brine from one vat to another; in the course of this operation, the fish are well washed and enveloped in brine and are shifted from the upper layers to the lower layers and vice versa. In order to shift fish from vat to vat and to create a conveying stream, in the vat containing the fish that are to be canted there is installed an aperture that emerges into the trough of a hydraulic conveyer or into an adjoining vat, and the vat containing the fish is overfilled with brine; the stream of brine pours out through the aperture and carries the fish from the vat.

The use of the method of overfilling the vat with brine instead of canting was proposed as early as 1936 by T. M. Borisov. He suggested arranging the pickling vats in steps one above the other and pouring the fish in cascades of brine from one vat into the other.

In 1940 the State Design Institute for the Fishing Industry (S. I. Gakichko), when it designed a plant for the pickling of sardine in circulating brine, adopted canting in a stream of brine, but with the usual arrangement of the vats on one level, at which the fish were poured from vat to vat through an aperture. Experiments on the feasibility of pouring fish with vats arranged in steps and on one level for a long time yielded no positive results. The fish floated up in the brine, approached the edge of the overflow, and stopped. The reason for this evidently lay in the structure of the mass of fish /257 floating in the brine.

[Please ignore space below; text continued on next page.]

In an attempt to create streams of brine that would break up the structure of the mass of fish floating in the brine, and would carry the fish away, the flow rate of the brine in the stepped vats and in the vats standing on the same level, was increased to 280 m^3/hour. Even a stream of these proportions, however, proved insufficient to pour fish in brine over the edge of the overflow. Yu. S. Pokrovskii solved this problem by proposing to rake the fish by hand over the edge of the overflow; under this arrangement, output per man-hour increased sharply in comparison with the results obtained from canting with a raker. This method of canting, which received the name of Pokrovskii's method, can also be used for unloading salted fish from a vat when the fish are being packed. The fish are unloaded into the trough of a hydraulic conveyer, which transfers them to a reticulate conveyer. The latter conveys the fish to the packing conveyer.

Experiments carried out in 1950 at the Yuzhno-Nevel'sk Combine confirmed the high efficiency of Pokrovskii's method in canting herring, which allowed this method to be included in the process of pickling in circulating brine.

As a result of experiments carried out in 1950, a system was developed for canting during the mass pickling of fish. In this system, the last vat in each row remained clear of fish and was filled with brine. At first the fish were canted in a vat situated beside a vat filled with brine. For canting, use was made of a portable pump, with which brine was pumped from the last vat into that containing the fish and overfilled it; the fish moved through the aperture into the vat containing the brine. At the end of the canting operation, the last vat was filled with fish, and the adjoining vat contained brine. The next vat in the row was then canted in the same way, and so on.

High-speed, highly efficient TsNSh-80, pumps, which were light and compact and therefore extremely convenient for moving around the plant, proved to be unsuitable for canting, since they easily became obstructed with scale and, in addition, at their normal number of revolutions per minute (2,900) tended to make the brine foam, which hindered the work. 4NF and 2.5NF pumps (sewage pumps) neither became obstructed nor did they promote the formation of foam.

Pumps of both types, however, had one shortcoming in common - the intake hose had to be primed every time that air got into the pump and whenever the pump was shifted from one vat to another. Both types of pump had return valves at the ends of their intake hoses, which made all movements of the hose in the vat extremely difficult. S-203 pumps proved to be the best for canting: they had automatic intakes and no return valve at their ends, were not disrupted by inleakages of air, did not become obstructed, were easy to move around and had a sufficient delivery.

With the use of the S-203 pump, a vat with a capacity of /258 eight tons could be canted by two workers in 30 to 40 minutes. In this space of time, six to eight times less fish could be canted by hand.

Supplying Brine

One of the main features distinguishing various methods of pickling is the place at which fresh brine is fed to the pickling vat. A distinction is made between upper and lower feeding (see Fig. 112).

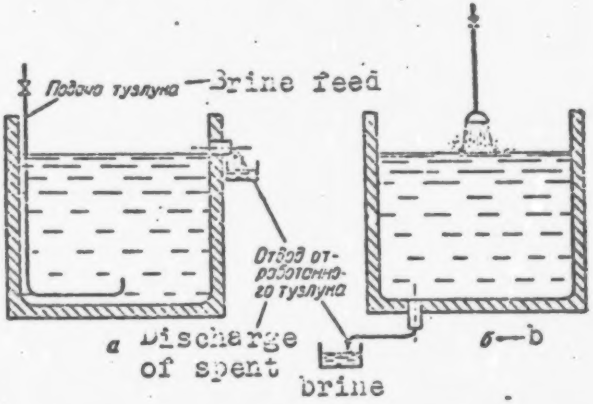

Подача тузлука
Brine feed
Отвод отработанного тузлука
Discharge of spent brine
a
б—b

Figure 112 - Diagram of the supply of brine to a pickling vat:

a - lower; b - upper.

Where brine is fed from above, it sprays the surface [of the brine] in the vat and is discharged through a pipe in the lower part of the vat. In the process there forms a considerable quantity of foam, which greatly hinders the work of the pickling system. Moreover, the supplying of brine from above does not promote a natural current of brine in the vat. Brine with reduced salt content, which forms in the process of pickling and has a lower specific gravity, tends to rise to the surface, while the fresh, saturated brine that is flowing in and has the greatest specific gravity, tends to sink to the bottom of the vat. Thus, in the vat are two streams of brine that move in opposite directions: a natural stream, based on the difference in specific gravity between the fresh and spent brine, and a forced stream established from the delivery pipe to the discharge pipe.

Where brine is supplied from below, it is delivered through a pipe to the bottom of the vat and is discharged from the vat's upper area, above the surface of the pressure grating. Under this arrangement, the possibility of foaming in the vat is reduced, /259 and a forced current of brine, corresponding to a natural current, is established.

Adherents of the supply of brine from above assert that when brine is fed from below, the pressure of the fish on the pressure grating increases. Moreover, the upper, compressed layer of fish in the vat is viewed as a semipermeable diaphragm that is under the pressure of a column of brine equal to the difference in the levels of brine in the supply tank and the vat (1.5 to 2 metres). We cannot agree with this assertion, since on the brine delivery pipe is installed a regulating valve that acts as a reducing valve and completely relieves the vat of the pressure created by the supply tank.

Unloading Vats

The unloading of salted fish from vats together with pickling is an extremely laborious operation. Vats are usually unloaded manually with the aid of lift nets - zyuz'gas or khvatkas on long wooden handles. In order to facilitate this process, brine has been added to the vats while they were being unloaded; simultaneously, the fish have risen to the surface of the brine. By gradually increasing the level of the brine in the vat, it has been possible to keep the fish at the same level near the upper edge of the vat, which has considerably lightened the work of the man occupied in pouring the fish out.

There are several proposals for mechanizing the unloading of vats using dry methods. For this purpose the use has been suggested of light, mobile cranes or bucket elevators. These machines require hand labour for loading their buckets.

Hydraulically mechanizing the unloading of pickling vessels ensures higher efficiency and almost excludes manual labour.

Attempts to apply hydraulic mechanization to the unloading of fish from vats were carried out repeatedly and were for a long time unsuccessful.

The first experiment was conducted at Kerch in 1939. It was proposed to use a brine monitor for "breaking off" salted anchovy from a pickling vat at Kerch refrigeration plant. A pump delivered brine through a fire-hose type nozzle at the rate of up to 30 m^3/hour.

The anchovy lay in the vat in a caked mass. When the nozzle with the spurting stream of brine was immersed in the mass of fish, a certain quantity of the latter was carried away by the brine, but on the whole the structure of the mass of anchovy was not broken, and they moved out of the tank fairly slowly. Experience has shown that a device of this kind does little to facilitate the work and does not accelerate it at all in comparison with pouring out by hand. This has been explained by the insufficient quantity of brine that is delivered. In this experiment, the monitor was used only for loosening the anchovy and not for getting it over the edge of the overflow.

A second experiment was set up in 1940 at the Moscow /260 Fisheries Combine. It was proposed to pour out of a vat small salted herring that were afloat in the brine and had just been loaded into the vat, i.e., they had not caked. There was brine in the lower vat, and the upper vat had also been flooded with brine to the edge of the overflow. The pump pumped brine from the lower vat and fed it into the upper, which thereupon overflowed, and the brine flowed over into the lower vat. Thus, in the system there was established a circulation of brine, whose current was to carry herring from the upper vat to the lower. The width of the overflow was 40 cm.

The brine consumption was 50 m^3/hour. The whole mass of herring floated up to the edge of the overflow and stopped near it; only individual fish were carried away by the brine. The failure of this experiment was again explained by the insufficient flow rate of the brine and the small size of the overflow.

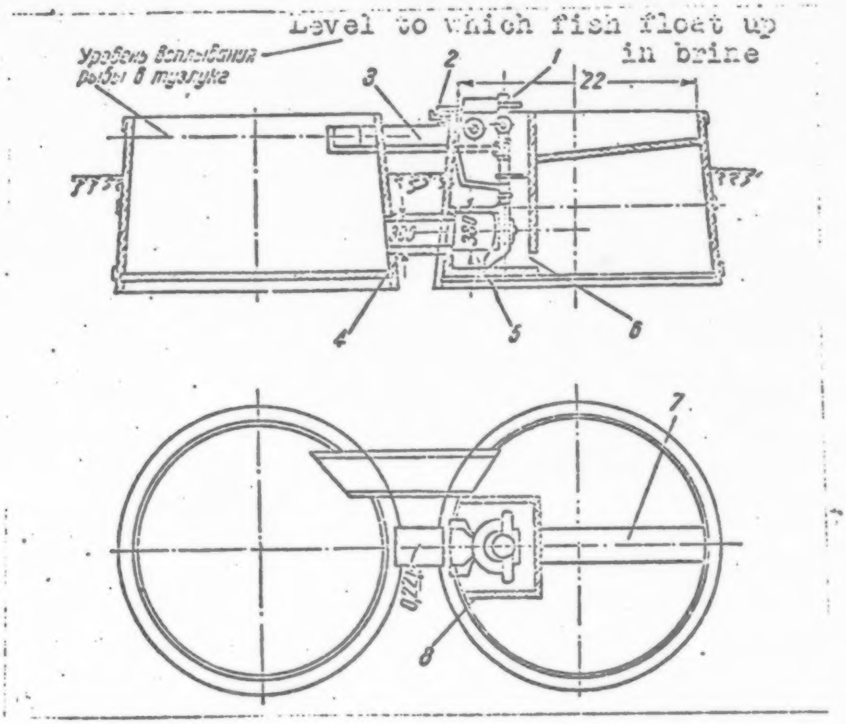

Level to which fish float up in brine
Уровень всплывания рыбы в тузлуке
1
2
3
4
5
6
7
8
22
380
300

Figure 113 - Diagram of an experiment on transferring fish from one vat to another with a propeller impeller pump:

1 - suspended A8 small boat motor with a screw propeller;
2 - installation bracket; 3 - overflow trough; 4 - delivery pipe;
5 - diffuser; 6 - aperture; 7 - small bridge; 8 - sump.

A third experiment on hydraulic transshipping (see Fig. 113) was set up in 1940 at the Klerk Fish Plant. Two vats were /261 equipped for the experiments. A propeller pump designed by the State Design Institute for the Fishing Industry /Giproryba 7, with a discharge of 151 m^3/hour and operated by a portable small boat motor was used as a pump. The width of the overflow was 25 cm.

Uncaked sardine were poured. In this experiment it was also observed that the fish floated in a block up to the overflow and were held back near it, and that the force of the current of brine was insufficient to break the structure of the block.

Finally, a fourth experiment involved tests of the pickling section of Borisov's system, carried out by M.A. Kazakov.

Thus, where the widths of the overflows ranged from 25 to 100 cm and flow rates of brine, from 30 to 151 m^3/hour, the results of the experiments were negative. This can be explained by the peculiarities of the mass of fish. In such a mass, when it is afloat, there are considerable forces of cohesion among individual fish. The block of fish, however, has a large number of cavities through which brine filters freely, breaking up into a large number of small jets. In the process, a large part of the energy of the jet of brine is lost, as a result of which the force of the stream is weakened. Finally, the distribution of the currents of brine in the vat is evidently such that these currents bypass the part of the block of fish that is sunk in the brine, this part serving as the foundation, as it were, of the entire block, on which the upper part of the block rests firmly; the brine filters through this upper part without breaking its structure.

Yu. S. Pokrovskii's method, described above, represents at the present time a workable method of unloading fish from a vat in a stream of brine. This method, however, requires the use of manual labour for raking the fish up to the overflow aperture.

Apart from Pokrovskii's method, in which the pickling vessel is unloaded by overfilling and using a monitor, salted fish may also be unloaded directly by a fish pump. Preliminary experiments set up at Kerch have shown that salted herring pickled in a vat may be pumped with an RB-100 fish pump whose wheel rotates at 800 rpm.

In tests of a unit for pickling tiulka in circulating brine according to the system of A.A. Timofeev, it was discovered that tiulka salted by this method were not injured in an RB-100 fish pump. In the process in which this unit was employed the tiulka were pumped three times with RB-100 fish pumps and remained completely uninjured. There is every reason to assume, therefore, that the method of pumping salted fish with centrifugal fish pumps will be widely applied.

A.P. Kruppa has proposed an unloading assembly and packing combine. On a small trolley is installed an NR-100 fish pump and a reticulate conveyer-brine separator, to the end of which is fitted a bin. The fish pump pumps the anchovy from the vat /262 and conveys them to the brine separator, which separates the fish and the brine. The latter flows back into the vat through a trough, while the anchovy first enter the bin and are then loaded in bulk into barrels.

A fish pump may be used in combination with a hydraulic conveyer removing salted fish for packaging on a special packing conveyer, which is more efficient both from the viewpoint of the organization of packing and with regard to sanitation and hygiene.

At the Osipenko Fish Plant an ejector fish pump, which was described in Chapter III, section 9, was used for unloading small fish from a vat into a hydraulic conveyer.

Making Calculations for a Brine-Conveying System

A brine-conveying system, consisting of a network of pipes, should ensure the conveying of brine to the following processes taking place at different times:

a) the removal from the vat of the remains of water that has entered the vat together with the fish from the fish pump;

b) the salting down of the fish;

c) removing fish from the vat during the canting and unloading of prepared salted fish.

Let us determine the rates at which brine is to be conveyed for pickling[1]. I.P. Levanidov gives the derivation of the formula for calculating the amount of brine for this purpose.

The common multiplicity factor of circulation K_{ts}, i.e., the ratio of the weight of the fish in the vat to the total quantity of brine flowing through the vat during the salting process, is taken as the basic value characterizing the intensity of salting

---

[1] In the first edition of our book, when the formula for calculating circulation was derived, errors were made that were pointed out by I.P. Levanidov. In particular, no allowance was made for the coefficients of solubility of salt in water and in brine, or for the decrease in the weight of the brine in connection with the reduction in specific gravity. There were a number of other inaccuracies as well.

$$\underset{\text{ts [circulation]}}{K_{ц}} = \frac{G_T}{G_{\underset{\text{r}}{p}}}, \qquad [83]$$

where: G_T is the weight of the brine flowing through the vat during the salting process;

G_r is the weight of the fish in the vat.

A certain quantity of salt, which is placed in the vat together with the brine, is required for salting a given quantity of fish. This quantity of salt at the beginning of pickling is constantly in the brine, and at the end of pickling is distributed in the fish and in the brine. It is evident that the quantity of salt at the beginning of pickling will be equal to the quantity of salt at the end of pickling; consequently, the following equation may be drawn up: /263

$$\frac{G_T \cdot c_1}{100} = \frac{100 G_T + G_p h}{100} \cdot \frac{c_2}{100}, \qquad [84]$$

where: c_1 is the concentration of salt in the brine at the beginning of salting, in %;

c_2 is the concentration of salt in the brine at the end of salting, in %;

h is the concentration of water in the tissue of the fish, in %.

It is evident that $\frac{100 G_T + G_p h}{100} \gamma$ is the total weight of the brine within and outside of the fish at the end of pickling.

Hence after transposition

ts [circulation]
$$K_{ц} = \frac{hc_2}{100(c_1 - c_2)}. \qquad [85]$$

Suppose that the content of salt in the brine at the beginning and end of pickling is respectively 26.4 and 25.4%, and that the content of moisture in the fish $\underline{h} = 75\%$, then

ts [circulation]
$$K_{ц} = \frac{75 \cdot 25.4}{100(26.4 - 25.4)} \cong 20,$$

i.e., for complete pickling a quantity of brine is required that is 20 times greater than the weight of the fish in the vat. It is evident that during individual periods of the salting process the partial multiplicity factor of circulation will change. In order to determine the greatest multiplicity factor of circulation during the period of the most intense salting, we shall determine the loss of moisture and the absorption of salt by the tissue of the fish during this period, whose duration we shall designate by θ. During the time θ the weight of the brine flowing through the vat will be increased by the quantity of moisture that will be lost by the fish, and will decrease by the quantity of salt lost by the brine to the fish

$$G'_T = G_T + \frac{G_T \cdot h'}{100} - \frac{G_p \cdot S}{100} \gamma, \qquad [86]$$

where: G'_T is the quantity of brine flowing through the vat in the time Θ;

h is the quantity of moisture given off by the fish during the same period, in %;

S is the quantity of salt absorbed from the brine during the same time, in %.

The quantity of salt in this amount of brine will amount to:

$$G_s = \frac{G'_T \cdot c_1}{100} - \frac{G_p \cdot S}{100}. \qquad [87]$$

The concentration of salt in the brine upon the expiration /264 of the period will amount to:

$$c'_2 = \frac{(G'_T c_1 - G_p \cdot S)\,100}{100\,G_T - G_p \cdot h' - Sh'}\ \%. \qquad [88]$$

Then

$$K_{ts} = \frac{G_T}{G_p} = \frac{h' \cdot c_2 + S\,(100 - c_2)}{100\,(c_1 - c_2)}. \qquad [89]$$

ts [circulation]

In order to obtain the flow rate of the brine with reference to the time Θ, we shall divide the right side of the latter equation by Θ and multiply by G_r.

Then

$$G'_T = \frac{G_p\,[c_2 h' + S\,(100 - c_2)]}{100\,(c_1 - c_2)\,\theta}. \qquad [90]$$

If G_r is in metres, and Θ is in days, then G_T is in tons per day.

The multiplicity factor of circulation should be the greatest in the first days of pickling. As observations have shown, however, the mass of fish in the vat has insufficient permeability during the first days of pickling. Therefore, an increase in the delivery of brine into the vat can lead only to the pressing of the fish in the vat, when the fish are transformed [as it were] into a piston and the vat into a cylinder, and this can cause the destruction of the vat.

Therefore, the greatest multiplicity factor with which the brine is conveyed should be referred to the period when the permeability of the mass of fish will increase, i.e., the fifth to sixth days of pickling.

According to the data of I.P. Levanidov, the multiplicity factor of circulation on the third day is 2.5, and the maximum multiplicity factor is about 9, which is in fact the calculation figure for determining the diameter of the pipe conveying brine.

Thus, if G_T tons/day has been calculated, the flow rate of brine by the hour and by the second may be computed, and from this can be determined the diameter of the brine-conveying pipe.

Since the remainder of the conveying water should be removed from the vat at a speed not greater than the normal circulation of the brine during the first period of pickling, and the maximum delivery of brine into the vat is several times greater than the delivery during the first period of pickling, the diameter of the pipe should not be calculated from the speed with which the water is forced out.

Recently, plants carrying out pickling in circulating brine have been equipped with brine conveyers for raw fish; thus, not water, but brine, which does not have to be removed at all, enters the vat together with the fish.

Foaming

Turbulent foaming in brine sumps, salt concentrators / 265 troughs and vats is occasionally observed in the operations of plants using brine for pickling. In some cases, the quantity of foam that has formed has been so great that operations in the plant have been suspended.

Observations have shown that foaming takes place as a result of the saturation with air of brine containing albuminous substances, subject to foaming, that have been drawn from the fish. Air enters the brine owing to leakages in pipes, the stuffing boxes of pumps, etc., and also when a free stream of brine discharges in the atmosphere. The use of high-speed pumps of type TsNSh for pumping brine and canting promotes foaming.

The experience gained during work in the fishing season of 1953 has demonstrated that when the quality of assembly is good, and leakages have been eliminated, foaming is reduced to a minimum and in no way hampers operations. The replacement of TsNSh pumps by S-203 pumps reduces foaming even further.

Pressure in the Vats

The delivery of concentrated brine into vats through a brine main directly by a brine pump occasionally leads, as experience has shown, to the destruction of the pressure gratings.

The greatest stress developed by the fish when they are pressing on the pressure grating is 1,000 to 1,500 kg, which corresponds to an areal pressure on the vat of 0.02 to 0.03 kg/cm^2. Ordinarily, the pressure gratings, which are made of rods with a cross section of 5 x 4 cm, easily withstand these pressures. In the fishing season of 1952, however, instances were observed of the breaking, under the pressure of the fish, of gratings and even of the wooden beams (2.2 to 2.3 metres long, and with a cross section measuring 10 x 10 cm) fastening them. An explanation of this was given by I.P. Kostromin, who measured the pressure in the lower levels of a vat using piezometric pipes. He established that this pressure is four to five times greater than the usual pressure developed by fish when they rise to the surface in concentrated brine, and demonstrated that the only source of this pressure can be the pump delivering brine to the vat. In the vat, the brine acts on the upper compressed layer of fish as on a piston, transmitting to the fish the pressure developed by the pump, which can reach 1.5 to 2 kg/cm^2. In order to reduce the pressure in the vat to normal, it is necessary to use greater care in regulating the opening of the valve on the brine pipe. In addition, I.P. Kostromin used sections of metal pipes 1" in diameter for automatically regulating the pressure in the vat: a pipe of this kind was inserted in the vat almost to the bottom, and extended 5 to 7 cm above the surface of the brine. When the pressure in the vat increased, the brine automatically ran out through the pipe, as a result of which the vat was relieved of excess pressure. Breakages of pressure /266 gratings have been eliminated by the regulating of valves and the installation of pipes for releasing surplus brine.

Labour Input

Observations in the course of experiments have shown that the labour input in plants where herring is pickled in circulating brine is equal to or somewhat less than that in plants where pickling is performed with dry salt. Practical comparative data, however, on the operation of plants pickling in brine have shown that 19 workers are required to handle a brine pickling plant as against 48 to 54 workers in ordinary pickling plants.

Salt Concentrators

In all experiments on the pickling of fish in circulating brine, operations were carried out with salt concentrators with a downward flow of brine. These salt concentrators were arranged in ordinary pickling vats or sumps. In the vat was installed a flooring at a height of 0.6 to 1 metre from the bottom. On the flooring was laid a filtering fibre on which salt was poured in a layer of up to 60 cm. The brine, flowing by gravity through the layer of salt, became saturated.

The efficiency of a salt concentrator of this type proved to be very low, and work with such concentrators on an industrial scale was inconvenient, since the filtering fibre had to be changed frequently, and, moreover, the salt concentrators did not work more than 3 to 5 hours.

E.G. Vechkanov has proposed and tested a salt concentrator with a forced rising current of brine delivered by a pump (see Fig. 114). The concentrator consists of a tank with a volume of 12 m^3, on the bottom of which is mounted a diffuser connected to a centrifugal pump delivering thin brine or water that is to be saturated. The tank is loaded with salt to 2/3 of its height. At the top of the tank is an overflow trough. The brine, emerging from the diffuser, passes up through the layer of salt and runs off through the trough into a sump, from which it is pumped either into a supply tank or directly into the brine system. Before [it enters] the sump, the brine passes through a filtering bin.

Tests carried out by E.G. Vechkanov at enterprises of the Ukrainian-Black Sea State Fisheries Trust have shown that a salt concentrator of this type saturates diluted brine in the amount of 200 m^3/hour and ensures the preparation of saturated brine of good quality, free of mechanical admixtures.

Observations of the operation of such salt concentrators on Sakhalin in 1952 showed that they can be a source of foaming. In order to prevent this, concentrated brine must be released /267 through a pipe under the surface of the brine on the filter, and the level of the brine in the salt concentrator must be kept above the discharge pipe

---

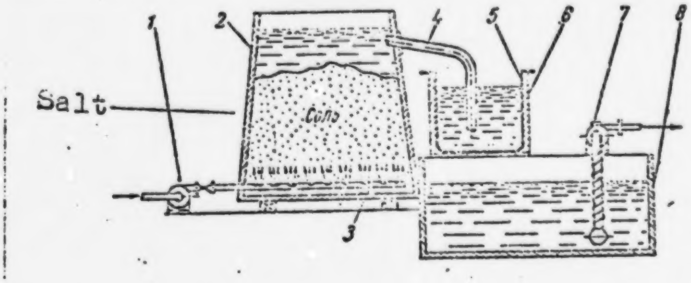


Figure 114 - Diagram of salt concentrator with rising current of brine:

1 - centrifugal pump for feeding liquid into salt concentrator; 2 - salt concentrator; 3 - diffuser; 4 - pipe for overflow of concentrated brine; 5 - filter; 6 - filtering receptacle; 7 - centrifugal pump for delivering concentrated brine into system; 8 - storage tank for concentrated brine.

The Sakhalin Division of the State Design Institute for the Fishing Industry /Giprorybprom7 (I.P. Kostromin) has designed a central brine station for an enterprise with a total pickling capacity at one time of 78,000 centners /7,800,000 kg7. This station (see Fig. 115) is situated near a salt dump* with a capacity of about 20,000 tons and equipped with conveyers for receiving salt. The dump is surrounded from below by sides /sic/, and under it are laid diffusers, through which liquid (diluted brine and water) is fed under the dump, washing away and dissolving the salt. The saturated brine that is formed runs off into a sump, from which /268 it is pumped into a supply tower (reservoir) whence in turn it proceeds under pressure through pipes to the pickling plants.

---

* Translator's note. A suggested equivalent of the Russian bunt, meaning "pile" or "stack".

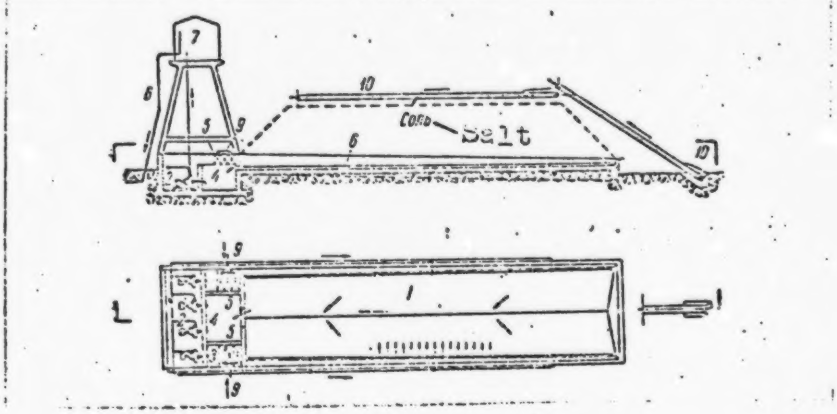


Figure 115 - Diagram of a central brine station:

1 - platform for salt; 2 - pumping compartment; 3 - diluted brine reservoirs; 4 - concentrated brine reservoir; 5 - filters; 6 - diffusers; 7 - supply tower; 8 - brine conduit to plants; 9 - return brine conduits; 10 - belt conveyers.

5. The Speed of Salting

The speed of salting is an essential factor in the process of pickling fish and acquires special practical importance where there is a shortage of pickling space.

The very first researchers into the process of pickling fish in circulating brine (T. M. Borisov, 1936-1939, and others) directed attention to the fact that the salting of fish in moving brine takes place faster than where pickling is performed with dry salt or in non-circulating brine, i.e., in a motionless agent.

According to the data of T.M. Borisov (from experiments that he carried out in 1939) when sardines were pickled in circulating brine salting was considerably accelerated in comparison with the usual commercial kinds of pickling (see Table 23).

[Please ignore space below; text continued on next page.]

Table 23

Accelerating the Pickling of Sardine with the Use of Circulating Brine

Designation of raw fish	Saltiness obtained, in %	Duration of salting, in days		Salting acceleration factor	Remarks
		in circulating brine	under ordinary commercial conditions		
Unfilleted sardine	14,5	4	12	3	Warm picklin
Decapitated sardine	13,3	4	8	2	

Subsequent studies of the process of pickling fish in circulating brine, carried out by a number of investigators (N.T. Berezin, A.V. Terent'ev, M.A. Kazakov, K.A. Bashkirov, N.I. Sukrutov, L.P. Minder, A.A. Timofeev, G.V. Gerasimov, E.G. Vechkanov and others) have yielded extraordinarily varied and frequently contradictory results and have made the question of the speed of salting debatable.

Berezin and Terent'ev, for example, when they pickled herring and bream in circulating brine, accelerated the salting process by six and seven times. In experiments with pickling sardine, Kazakov derived an acceleration factor equal to 1.2. Minder, as a result of experiments on pickling anchovy in circulating brine, concluded that this method of pickling was completely inapplicable to anchovy, and that no /269 acceleration whatever of salting was involved in the circulation of brine as compared with pickling with dry salt.

Timofeev proposed, produced and tested a unit for pickling anchovy and *tiulka* /*Clupeonella d. delicatula*7 in a free state in circulating brine and achieved extremely favourable results: a high-quality salted product with an acceleration of the salting process by 12 to 15 times.

Gerasimov suspended separated pieces of fish in brine and observed their salting both in stationary and moving brine. Here the composition of the brine was in both cases completely equal, as were the sizes and quality of the pieces of fish undergoing salting. The pieces that were placed in moving and stationary brine were cut from two fish that were themselves completely equal in weight, geometric dimensions and fatness. The pieces were cut from the same part of the body; hence, the greatest similarity of both pieces was achieved and the obtaini of comparable results was ensured. Small fish - Baltic herring and smelt - were salted in the same way. The results of the pickling of fish in moving and stationary brine are given in Table 24.

A. N. Voskresenskii found that in Timofeev's unit the average salting speed was 6.7% per hour as against 5.95% per hour in ordinary vat pickling, or that the acceleration factor amounted to a total of 1.12.

It must be noted that the inconsistency of the data in this matter results from the fact that all of the experiments were carried out under different conditions, and that the acceleration factor was derived from comparison with diverse and arbitrarily selected values.

It is evident that the most correct will be the opinion of I.P. Levanidov, who considers that the salting acceleration factor of pickling in circulating brine, as compared with salting with the ordinary method, lies within the limits of 1.1 to 1.2.

6. Basic Systems of Pickling Fish in Circulating Brine

The System of T.M. Borisov

The essence of this system (see Fig. 116) lies in the fact that the fish are salted in circulating brine which is delivered from above, and that in the process of pickling they are canted several times by being cascaded from vat to vat in a stream of brine.

The system consists of a row of vats arranged in steps. The upper vat serves as a receptacle for the fish, while from the lower vat the fish are delivered to a hydraulic trough conveyer and are sent for packing. The brine circulating in the system is removed from below the pickling vats and is delivered by a pump to a filter, a salt concentrator and a refrigeration unit, which are situated apart and work under pressure. The brine is then delivered by a second pump to a brine-conveying conduit that is distributed among the vats.

Preliminary tests (on a laboratory scale) of a unit operating under Borisov's system have yielded satisfactory results. The salted sardine had an excellent commercial appearance, and normal saltiness (up to 14.5%), which was achieved on the fourth day of pickling, i.e., with considerable acceleration.

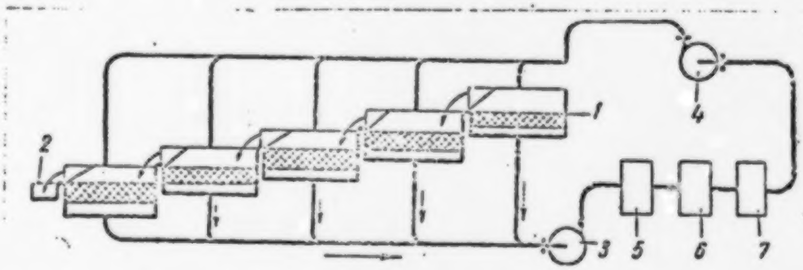


Figure 116 - Diagram of a section for pickling in circulating brine according to the method of T.M. Borisov:

1 - pickling vats; 2 - hydraulic conveyer for salted fish; 3 - pump for pumping spent brine; 4 - pump for delivering concentrated brine; 5 - filter; 6 - salt concentrator; 7 - refrigeration unit.

When Borisov's method was tested on a pilot plant unit, the operation of transferring the fish from vat to vat was not successfully carried out. Now that the problem of getting the fish over the edge of the overflow has been solved, the unit in Borisov's system can be completely tested. The arrangement of the unit in the form of stepped vats, however, will hardly prove economical, since it requires the creation of expensive structures and does not correspond to the conditions of herring fishing, in which herring are caught in large quantities simultaneously.

The System of N.T. Berezin

This system (see Fig. 117) is based on the salting of fish in brine circulating in ordinary vats equipped with a brine conduit and overflow troughs (for the brine), with the brine fed from below.

The working mixture emerges from the delivery conduit of a fish pump, enters a hydraulic trough conveyer, passes through a grating, where the main body of the water is disposed of, and enters the vat.

When the vat is filled with fish, the gratings are closed and saturated brine begins to flow through the conduit to the bottom of the vat. The brine spreads over the bottom, and, rising up, forces the residual water out through the aperture into the overflow pipe leading to the reconcentrator.

In experimental models of the unit the reconcentrator, or /272 salt concentrator, was also installed in an ordinary pickling vat. Where necessary, ice was added to the salt concentrator (from above the salt). In this case it [the salt concentrator] could act as a cold producer, regulating the temperature of the brine, and, consequently, the temperature of the pickling as well.

The fish were held below the surface of the brine with pressure gratings.

Brine was fed into the system or into a supply tank by a centrifugal pump.

Tests of pickling in circulating brine by the method of N.T. Berezin have been carried out for a number of years under various conditions. With the use of this method Dagestan herring (shad and semi-black-backed shad*) were salted with warm brine; Caspian herring at Astrakhan, with cold brine; Far Eastern sardine, with cold brine, and Sakhalin herring, with warm brine. All of the experiments yielded good results. Where this method was applied, herring of excellent commercial quality was obtained. The main thing was that in no other processing method could such a high output per man-hour be obtained in pickling.

The use of Berezin's system (in the form that we have described) for pickling small fish yielded negative results. Thus, the field in which this method may be applied remains the pickling of medium-sized fish, i.e., herring, sardine, roach, etc.

---

*Translator's note. This English term is merely a literal rendition of the Russian poluzalom, for which no other suitable equivalent is available. The Russian prefix polu- means "semi-" or "half-", while zalom means "black-backed shad" (Alosa k. kessleri).

Table 24

The Results of Salting Fish in Moving and Stationary Brine

(according to the data of G.V. Gerasimov)

Name of fish	Elements salted	Size in cm		Weight, in g		Salting time, in minutes	Brine		Resulting saltiness of flesh in %		Salting acceleration factor
		in stationary brine	in moving brine	in stationary brine	in moving brine		Temperature in °	saltiness in %	in stationary brine	in moving brine	
Fresh-frozen carp	Pieces	5×3×1	6×3×1	23,5	20,5	30	—	22,1	5,8	12,5	2,1
		5×3×1	5×3×1	25,5	21,4	60	—	—	7,5	—	—
Fresh-frozen navaga	"	5×3×1,5	5×3×1,5	20,0	20,0	30	—	—	5,8	11,4	2,0
		5×3×1,5	5×3×1,5	22,0	18,0	60	—	—	8,2	14,2	1,7
		5×3×1,5	5×3×1,5	23,0	20,0	90	—	—	9,3	14,2	1,4
Fresh frozen Baltic herring	Whole fish	12,0	12,0	23,5	23,5	30	+16	22	3,0	14,0	4,7
		12,5	13,0	22,0	20,5	60	+16	22	2,9	15,6	5,4
Fresh frozen smelt	"	15,0	14,0	33,0	30,0	30	+16	22	4,9	9,0	1,8
		15,0	15,0	28,0	31,5	60	+16	22	6,8	10,0	1,4
		14,5	15,5	26,5	28,5	90	+16	22	9,3	18,1	2,0

Note. In all cases, the volume of the stationary brine was 1 litre, and that of the moving brine, 4 litres.

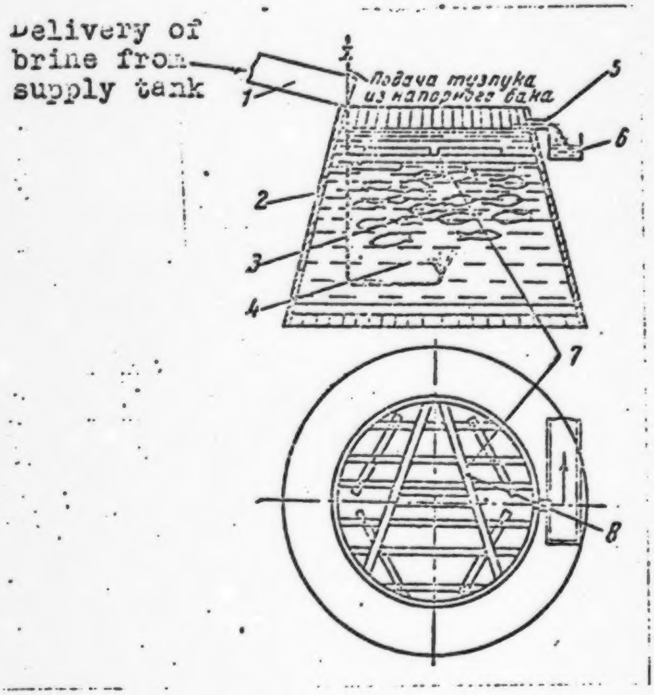

Delivery of brine from supply tank
Подача тузлука из напорного бака
1
2
3
4
5
6
7
8

Figure 117 - Diagram of pickling fish in circulating brine by the method of N.T. Berezin:

1 - delivering hydraulic trough conveyer; 2 - pickling vat; 3 - fish; 4 - brine; 5 - branch overflow pipe; 6 - trough for diverting diluted brine to salt concentrator; 7 - sectional pressure grating; 8 - A-shaped fastening of grating.

Nonetheless it must be acknowledged that even within these limits, the field of application of Berezin's system is quite extensive.

The Mechanized Pickling of Small Fish in Circulating Brine with Continuous Stirring

The pickling in circulating brine of small fish- anchovy, tiulka, etc., at first encountered a number of difficulties that seemed to be insurmountable.

L.P. Minder, when he placed anchovy in net bags and /273
loaded them into saturated brine, observed that under these conditions the anchovy were very poorly salted and spoiled.

In 1948, A.A. Timofeev and simultaneously E.G. Vechkanov began experiments on pickling tiulka in circulating brine. The brine and fish were continually mixed with mixers of different kinds, and the fish and brine were slowly conveyed in baths 40 to 80 metres long.

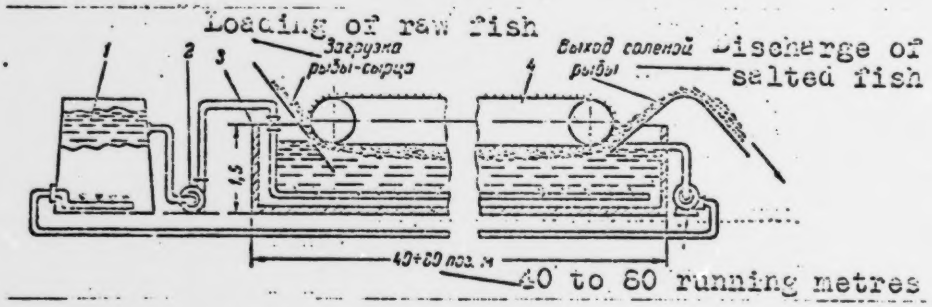

Loading of raw fish
1
2
3
Загрузка рыбы-сырца
4
Выход соленой рыбы
Discharge of salted fish
1,5
40÷80 пог. м
40 to 80 running metres

Figure 118 - Line diagram of an apparatus for pickling small fish in circulating brine with continuous mixing:

1 - salt concentrator; 2 - centrifugal pump for conveying concentrated brine; 3 - pickling bath; 4 - conveyer (shown conventionally); 5 - centrifugal pump for conveying diluted brine to salt concentrator.

N.T. Berezin expressed the hypothesis that during pickling, a film of diluted brine preventing the penetration of salt into the fish, formed on the surface of the latter; the destruction of this film by intensive mixing, he believed, would create conditions for accelerating salting. This hypothesis is at the basis of the units of A.A. Timofeev and E.G. Vechkanov, in which fish and brine are actively mixed. The design of the bath, mixers and means of conveyance in units of this type is important and frequently determines the success or failure of the work. Line diagrams of Timofeev's and Vechkanov's units, however, can be depicted in the same way (see Fig. 118). It may be seen in this diagram that the mixing of the fish in the brine is combined with its movement along the bath.

A. A. Timofeev, for the conveying and simultaneous mixing of fish in a bath in a unit built at Dolzhanskaya Kosa, used paddle wheels like those on a ship. A distinguishing feature of Timofeev's unit was the multiple pumping of tuilka by an RB-100 fish pump: first, during unloading from the fishing vessel, when the fish were mixed with water; the second time, when the fish were loaded into the pickling vat mixed with concentrated brine, and the third time, when the salted fish were unloaded from the pickling vat. The pumping of raw tiulka in concentrated brine with increased turbulence helped the fish to assimilate the salt at the very beginning of the salting process. As observations demonstrated, the triple pumping of the fish by the fish pump did not increase the amount of mechanical injury as against that ordinarily suffered. /274 Timofeev's unit put out tiulka with a saltiness of 12.6% with the temperature of the tiulka at 26° after 83 minutes of pickling and showed that it could handle 15.2 tons per hour of raw fish, i.e., it fully received for processing all fish delivered by an RB-100 fish pump - the head unit of the first cycle.

Timofeev's unit is still operating, although its design is fairly complicated and does not fully meet operational requirements. Thus, the main mixing and conveying mechanism - the rotors - is cumbersome and easily damages fish and throws them out of the bath and onto the ground. These factors have evidently prevented the further extension of units of Timofeev's system beyong the bounds of the one fish plant.

In Table 25 are given the results of observations of the pickling of tiulka in Timofeev's unit.

In this unit, E.G. Vechkanov used a scraper conveyer for conveying fish in the bath; this conveyer grasped the fish with the scrapers of its lower arm and moved them through the brine. Three forms of mixing pneumatic, mechanical and hydraulic - were tested on the fish and brine in the unit in order to accelerate the salting process. Pneumatic mixing was achieved by blowing compressed air into the bath through a diffuser laid along the entire length of the bath. For the mechanical mixing of the fish in the brine, rotors with blades in the form of rods covered with small rubber pipes weres fastened to the scraper conveyer.

Table 25

The Dynamics of Salting Tiulka in a Unit of a System of A.A. Timofeev

Place where samples selected	Duration of experiment, in minutes	Salt content in %						Average content of salt in % during six experiments	Specific gravity of brine	Temperature of brine in °
		Experiment number								
		1	2	3	4	5	6			
Upon emerging from loading conduit at beginning of bath	2,75	5,55	5,35	5,35	5,2	—	—	5,36	1,2	26,0
Upon being unloaded from pickling bath in front of fish unloading pump	78,50	11,1	10,3	10,14	11,35	10,8	11,9	10,81	1,2	26,0
After being unloaded by fish pump and after brine has run off	83,00	13,1	12,35	12,45	—	—	—	12,63	1,2	26,0

The rods were rotated when the conveyer moved. Hydraulic mixing consisted in delivering concentrated brine into the bath through a diffuser at a pressure of 1 atmosphere. At the same time, the fish in the bath were heavily sprayed from above with a shower.

The best mixing method, as E.G. Vechkanov indicates, was the hydraulic, in which the greatest intensity of salting was obtained. Mechanical and pneumatic mixing, as well as spraying with brine that flowed from a shower at a pressure of 1 atmosphere, caused excessive foaming of brine in the bath. A combination of simultaneous mechanical and hydraulic mixing did not accelerate salting, while the application of only one intensive spraying with brine from above without any mixing reduced the speed of salting as against salting with mixing. The temperature of the brine during E.G. Vechkanov's experiments varied within a range of 5 to 15° ; at 5° the speed of salting decreased by 5 to 8% in comparison with the speed at 15°.

Where hydraulic mixing was used, the saltiness varied from 13.2% in the lower level of a layer of fish to 12% in the upper level. With mechanical mixing, the saltiness varied from 12.1 to 12.7%, i.e., the variation of the pickling dropped somewhat.

In the case of mechanical mixing, the quantity of fish with mechanical injuries (burst fish) was 4.2%; where mixing was performed hydraulically, this figure rose to 6%. This also confirmed that the hydraulic method stirred the fish more intensively in the brine.

The observations of E.G. Vechkanov have also shown that the best results are obtained from pickling in saturated brine. The results of pickling tiulka on E.G. Vechkanov's unit are given in Table 26.

Vechkanov also observed that the loss of moisture from the fish during pickling in his unit was 8 to 10% 30 minutes after pickling began. On the basis of this, he proposed to introduce his unit into a barrel pickling line as a salting apparatus. The semifinished product which emerged from the bath was mixed with salt and spices in a mechanical pickling apparatus. The semifinished product was subsequently poured into a barrel standing on a vibrator; Vechkanov affirmed that this barrel, without a period of settling and addition /of further salt/fish7 could then be sealed and shipped at once.

The studies of A.A. Timofeév and Vechkanov have permitted the creation of a complex line for the high-speed mechanized pickling of tiulka.

The studies of A.E. Ragulin and L.P. Minder on the pickling of anchovy (a fatter fish than tiulka) in circulating brine with continuous mixing did not yield any favourable results in the autumn fishing season of 1951. These experiments, however, cannot be considered to have been exhaustive and must be continued.

500

Table 26.

The Dynamics of Salting Tuilka in a Unit of a System by E.G. Vechkanov

Conditions of experiment	Saltiness of fish in % depending upon time in minutes								Temperature in °
	30	60	90	120	150	180	240	300	
Pickling in concentrated brine with mechanical mixing	5,1	7,45	9,05	10,35	12,4	—	—	—	From 5 to 15
Pickling in concentrated brine with hydraulic mixing	5,05	7,75	9,60	10,85	12,6	—	—	—	
Pickling in brine with a specific gravity of 1.16	—	8,20	-	9,90	—	—	—	—	
Pickling with spraying and without mixing	—	—	—	—	9,5—11,1	—	—	—	15
Pickling at reduced temperature	—	—	—	—	9,6—10,9	—	—	—	5
Prolonged pickling	—	—	—	—	12,7	13,4	13,4	14,8	

Salting Large Fish in Brine in Containers

/278

The process of pickling large fish - cod, salmon and large run-of-the-mill species (the latter as a semifinished product for smoking and sun-curing) has now begun to be mechanized.

The problem of mechanizing the pickling of large fish is considerably more complicated than mechanizing the pickling of small and medium-sized fish. In order to salt small and medium-sized fish it is sufficient to mix them with salt or brine, but large fish, apart from a simple coating of their outer surfaces with salt, must also have these surfaces rubbed with salt; in addition, the abdominal cavities and gill chambers of fish that have first been eviscerated must be packed with salt.

Thus, in order to pickle fish with dry salt , it is necessary to mechanize processes that are kinematically highly complex.

I.D. Usov's attempts to create a machine for pickling salmon with dry salt yielded no favourable results for three years. Moreover, when dry salt is used, additional processes are necessary, for example, washing the fish after it has been salted. This process is extremely laborious and very complicated, since not only the outer surfaces of the fish, but also their internal abdominal cavities, must be washed with brushes. In a number /277 of cases, large fish are packed in rows into vats.

Mechanizing the unloading of large salted fish from vats also presents considerable difficulties. Where hydraulic methods or the scooping up with a lift net of fish floating in the brine are practicable for mechanizing the unloading of small and medium-sized salted fish from vats, these methods are inapplicable to large salted fish, since eviscerated, heavily salted cod and salmon do not float, but rather sink in saturated brine. Hence the use of circulating brine for mechanizing the pickling of large fish becomes complicated, since its use involves, as we saw above, canting, i.e., the transfer (loading) of fish from vat to vat, or continuous mixing in brine.

The solution of the problem of mechanizing the pickling of large fish could be to pickle the fish in circulating brine in containers, i.e., in latticed boxes immerses in a vat containing circulating brine. The loading and unloading of the vats, and, consequently, canting, could be mechanized with the use of a container moved by a telpher along a monorail.

In recent years several experimental studies have been made on the pickling of large fish in containers.

In 1951, N.I. Sukrutov (Astrakhan Division of VNIRO) conducted experiments on pickling bream and roach in container boxes with a capacity of 90 kg that were immersed in vats containing chilled, circulating, saturated brine at a temperature of no more than 6° (see Fig. 119).

Simultaneously, control pickling was carried out by the usual method, i.e., with the interspersion of salt and crushed ice and triple canting. The experiments showed that the fish placed in boxes were salted somewhat more rapidly than by the usual method, that a high-quality product was obtained, and that the quantity of mechanical injury to the fish decreased.

The coefficient of use of the pickling space was 0.8 of the coefficient of use of the space during ordinary pickling.

This method found industrial application at the city of Astrakhan.

At the Murmansk Fisheries Combine in 1952 Comrades Sobolev, Sal'nikov and others carried out experiments on pickling cod in circulating saturated brine in containers. The container was immersed in a bath measuring 1.33 x 1.22 x 1.28 metres; it consisted of a latticed box with a volume of 1.8 m^3 and a capacity of 1.4 tons of fresh filleted cod.

The temperature of the brine in the experiments ranged from 13.6 to 15.3°, and the duration of the salting, from 110 to 131 hours, while the speed of circulation of the brine was maintained within the limits of 2.0 to 4.7 litres per second.

Fresh fish (large, medium and small) coming from a trawler in approximately equal quantities were loaded in bulk into a container. The container was weighed before and after being filled with fish. In order to determine the amount of /278 /̲fluid_7 escape /̲from the fish_7 during pickling, the fish proceeding to pickling were tagged. The fish that were intended for determining the escape /̲of fluid_7 were weighed one by one, and marked with tags; then 20 fish of each size were loaded into each container. The fish that were marked with tags were pickled together with all the other fish; in addition, the marked fish were put into all of the layers, from top to bottom, of the fish-filled container (upper, middle, and lower).

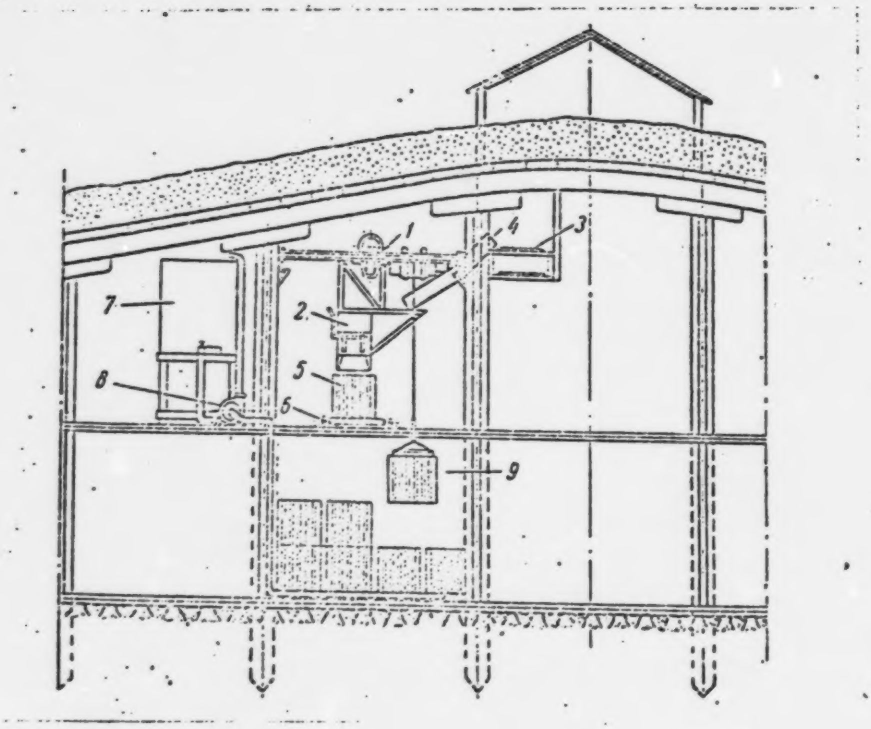


Figure 119 - Diagram of container pickling of fish:

1 - combined beam and crane; 2 - loading device for pouring fish into conveyer box; 3 - delivering conveyer; 4 - trough; 5 - container; 6 - roller convyer; 7 - supply tank for brine; 8 - centrifugal pump for circulating brine; 9 - pickling bin equipped for the circulation of brine.

During the pickling process, every four hours after the fish were loaded in, the concentration and temperature of the brine, as well as the speed at which it flowed out through the overflow aperture of the bath, were measured. Every 24 hours the fish were examined and samples were selected [to check], the [illegible] salt and moisture. When the samples were selected, fish were taken of all sizes and from all layers of the container (upper, middle and lower). After the fish had been brought to a high level of saltiness, pickling was discontinued. The container was removed by the telpher from the pickling bath, weighed and brought up to mounted trolleys. The bottom of the container was then tilted and the fish poured /279 out into the trolleys. The tagged fish were weighed after pickling, and from the difference in weight before and after pickling was determined the amount of [fluid] that had escaped during pickling.

For comparison, a combined control pickling of fresh fish was carried out parallel to the experiment in pickling fish in circulating brines. The experiment was carried out with the same fish and in the same container placed in a bath situated beside the bath in which the fish had been salted in circulating brine.

In this case, the fish that were selected were rubbed with salt before being pickled. The dosage of salt applied to the raw fish amounted to 15%. The fish were put in bulk into the container, which was immersed in the bath. After [each] day of pickling, brine with a specific gravity of 1.20 was fed into the bath. In order to determine the amount of [fluid] escape, tagged fish were included in the pickling. The selection of samples to ascertain the content of salt and moisture in the flesh of the fish was carried out at the same time as the selection of samples of fresh fish that had been salted in circulating brine. The results of the experiments are given in Table 27.

Table 27

Saltiness and Escape [of Fluid] (in %) during the Pickling of Fresh Cod in Containers in Circulating Brine

Size of cod	Pickling in containers in circulating brine		Controlled pickling (combined)	
	Saltiness of fish flesh	Weight loss (escape [of fluid])	Saltiness of fish flesh	Weight loss (escape [of fluid])
Large	12,2	13,2	8,6	14,2
Medium ...	13,1	14,0	10,2	16,2
Small	13,9	13,7	12,4	17,1

The experiments showed that with pickling in containers in circulating brine it is possible to salt normally as large a fish as cod. Characteristic of these experiments were the dimensions of the containers, which were close to those that should be used under industrial conditions.

On Sakhalin, I.P. Levanidov is conducting experiments on the pickling of salmon, primarily pink salmon, in containers.

The experiments that we have described on the container pickling of run-of-the-mill species of fish and cod are not definitive. Nonetheless, they have laid the foundations for developments in the mechanization of pickling large fish, including salmon.

The Pickling of Herring in Airtight Vessels in Circulating Brine

When developing methods of mechanizing the pickling of herring on expeditionary ships in the North Atlantic, researchers ran into the problem that the deck of the medium fishing trawler was extremely encumbered with machinery, which involved considerable/280 inconvenience for the crew.

The group of researchers (A.V. Terent'ev, N.T. Berezin, I.P. Levanidov, P.A. Petrov, V.S. Petrov and V.P. Sokolov) proposed to transfer the pickling from the deck to the hold of the trawler, using the method of hydraulic mechanization for this purpose. Since the presence on the ship of vats with an open surface and freely poured brine was inadmissible from the viewpoint of the ship's stability, it was proposed to carry out pickling in circulating brine in the following vessels which would be tightly closed and filled to the top with brine: metal tanks divided vertically and horizontally by detachable gratings into a number of compartments in which the fish would be relieved of pressure from the lower layers; metal tanks filled with latticed boxes containing fish, and ordinary flooded barrels.

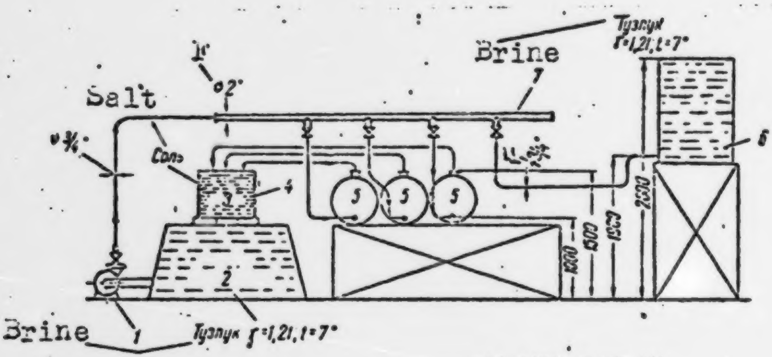


Figure 120 - Diagram of an experimental unit for the pickling of herring in barrels of circulating brine:

1 - circulating pump; 2 - vat for concentrated brine; 3 - salt concentrator; 4 - filter; 5 - barrel containing herring; 6 - small supply tank for brine; 7 - manifold.

At Murmansk in 1955 A.V. Terent'ev conducted an experiment in pickling Murmansk herring in circulating brine in barrels according to the system depicted in Fig. 120.

The experiments showed that when herring were pickled in barrels of circulating brine to a high degree of saltiness, a high level of uniformity in the salting was also obtained. In order to achieve this, the method of periodically pouring off the brine (an imitation of canting) was used: the barrel was taken out of circulation, the brine was poured from it, and the barrel was then once more included in the system of circulation.

The experiments are now being continued under commercial conditions at sea. The successful completion of these experiments will permit the multiple mechanization of pickling on board expeditionary ships, which will lighten the labour of the fisherman.

Chapter XI

/221

A LINE FOR THE MULTIPLE HYDRAULIC MECHANIZATION OF FISH-PROCESSING ENTERPRISES

In the Soviet Union there are more than 50 systems for the multiple mechanization of fish plants. A considerable number of these are based on the use of hydraulic mechanization. Most of the systems are concerned with mechanizing the pickling of fish (anchovy, tiulka, sprat, Baltic herring, herring, salmon and cod), and only a few, with mechanizing the production of refrigerated fish. Until recently, schemes for hydraulic mechanization encompassed only the pickling of fish; only in 1954 did the system of hydraulically mechanized refrigeration described in Chapter X, appear.

In this book we present certain well-known systems, some of which refer to those that are in operation, while others are prospective, i.e., they must be studied and verified experimentally.

1. A Mobile Line for the Pickling of Small Fish in which the Raw Fish are Unloaded by Fish Pump and Conveyed through Pipes (see Fig. 121)

The raw fish (anchovy, tiulka and sprat) that are delivered in large transport or fishing ships (launches, seiners, motor boats, dubs*, scows, etc) and in small craft (baidy*, kayuks*, boats, etc)

Translator's note. A dub is a wooden sailing vessel up to 60 metres long operating off the northwest coast of the Black Sea. A baida is a fishing sailboat on the Sea of Azov. A kayuk is a small flat-bottomed river boat with two oars. No suitable English equivalents are available for these terms.

are unloaded by a complete RBU-100 fish pumping unit. Water is poured into the hold of the ship with a TsNSh-80 pump, and the intake hose is shifted with a swivel cantilever crane with a load capacity of 500 kg, mounted in a gantry frame.

The crane is not included in the line unit that is supplied by the factory and should be delivered separately.

The TsNSh-80 pump pumps water from over the side of the fish-carrying ship into its hold, where there forms a mixture of water and fish in ratios of 1:4 to 1:5. If the hold of the ship is full of fish, a depression 30 to 40 cm deep is dug in the fish with a zyuz'ga*; into this depression is placed the intake hose of the fish pump, and a stream of water from the flooding hose is aimed at the fish.

For the pumping out of raw fish from large ships the fish-pumping unit is equipped with a normal intake valve. If the fish is delivered in very small ships, the RBU-100 fish-pumping unit is equipped with a combined valve.

A working mixture is transmitted under pressure from /282 the wharf to the pickling platform through hoses 150 mm in diameter laid along the ground for a distance of 150 to 200 metres. This distance is surmounted by the pressure head of the fish pump on condition that the rise in the terrain does not exceed 2 to 2.5 metres.

---

* Translator's note. See Translator's note. P 214.

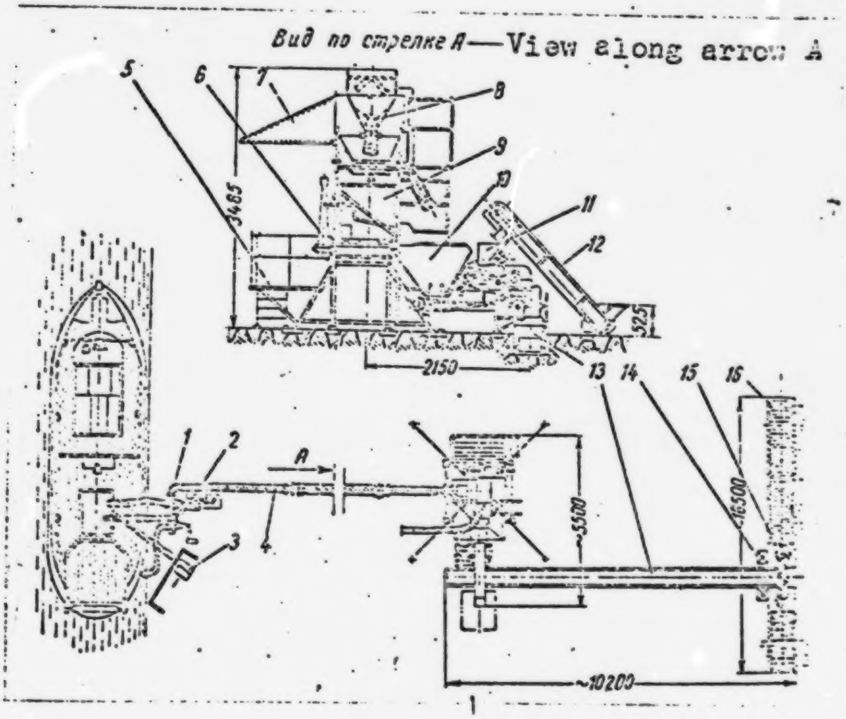

Вид по стрелке А—View along arrow A
5
6
7
8
9
10
11
12
3485
325
2150
13
14
15
16
1
2
A
3
4
5500
16500
~10200

Figure 121 - Mobile line (for pickling small fish) in which raw fish are unloaded by a fish pump and conveyed through pipes:

1 - RBU-100 fish-pumping unit; 2 - TsNSh-80 flooding pump; 3 - crane; 4 - fish conduit made of hoses; 5 - servicing platform; 6 - centesimal scales; 7 - awning over platform; 8 - water separator; 9 - weighing bins; 10 - feeder bin for fish; 11 - feeder bin for salt; 12 - worm conveyer for supplying salt; 13 - belt conveyer; 14 - spreader-mixer; 15 - vibrator; 16 - roller conveyer.

The working mixture passes from the hose to a cascade water separator designed by the State Design Institute for the Fishing Industry [Giprorybprom]. The water separator is part of the main processing assembly which, after the water has separated, weighs and measures out the fish and salt, mixes them, and transfers them to vats and barrels. All units of the assembly are mounted on sectional [collapsible] metal structures. The assembly is designed for pickling fish in barrels, but is also used for vat pickling.

The water separator requires thorough maintenance and frequent regular scraping of algae, scales, etc, from its perforated surfaces.

From the water separator the fish pass to a maneuverable /283 distributor trough. The distributor directs the stream of fish into weighing bins. The latter are mounted on centesimal scales equipped with an automatic electromagnetic switching device. When the weight of the fish in the bin reaches 100 kg, (the amount of a single loading of fish into a 100-litre barrel), this device causes the slide of the bin to open, and the fish are released into a feeder bin; at the same time, the maneuverable distributor trough is shifted to another position by pull cables.

The weighing bin has a sloping perforated bottom and a bottom pan; an additional separation of water, after that performed by the water separator proper, takes place in this bin.

The remainder of the fish (from the lot that has been received), which weigh less than the batch given to the automatic machine, are weighed and released from the bin by hand, for which there is a special lever.

In order that the readings of the scales will not be distorted, the weighing bins are not situated in the centre of the scales platform. So as to balance the platform and regulate the scales, a counterweight in the form of a box containing ballast is put on the platform.

The feeder bin, which the fish enter from the weighing bins, is tapered and is located above a belt dispenser-feeder, whose belt represents the bottom of the feeder bin. The latter has in its forward wall a rectangular opening that is closed with a slide plate. When the slide plate is opened, in the bottom of the feeder bin there opens an outlet through which the fish flow out of the bin.

The discharge of fish from the feeder bin results both from the fact that they are poured out and from the effect of adhesion to the moving belt on which the fish lie. The speed at which the fish flow from the feeder bin depends upon the extent to which the slide gate is opened; this latter value is indicated on a dial on the control wheel of the controls. The slide gate admits from 10 to 25 tons of fish per hour.

Technical Description of a Belt Batcher for Fish

Maximum output, in tons per hour	25
Speed of belt in metres per second	0.22
Power of electric motor in kw	1.7
Distance between edges, in mm	490
Width of belt, in mm	500
Distance between centres of drive and tension drums, in mm	1,500

The fish passing from the feeder bin to the belt are strewn with salt from a second belt batcher located above the belt of the fish batcher. The salt batcher is installed in the same way as the fish batcher, and above its belt it has a feeder bin for salt whose opening is closed with a slide gate. The slide gate is controlled by a system of levers and pull rods that is connected to the system for controlling the slide of the feeder bin for fish. The opening of the aperture of the feeder bin /284 for salt is regulated for a definite program of pickling depending upon the opening of the slide gate of the feeder bin for fish.

Technical Description of Belt Batcher for Salt

Maximum output, in tons per hour	5.0
Speed of belt in metres per second	0.049
Distance between edges, in mm	490
Width of belt, in mm	500
Distance between centres of drive and tension stations, in mm	600

If the assembly is working on barrel pickling, the batcher-feeders for fish and salt are regulated for the output of the line and of the fish pump. Owing to this, every standard batch from the automated scales will follow in succession at intervals of 2 to 3 seconds, and thus a certain standard batch of fish will enter each barrel, which is necessary in barrel pickling.

Salt is fed into the feeder bin by a worm conveyer from a dump located near the assembly. The screw of the worm conveyer is equipped with special bosses that help to crush the lumps of salt. In spice pickling the worm conveyer delivers, for the salt, a mixture of salt and spices that is prepared separately.

The belt batcher-feeder for fish is set in motion by an electric motor through a reducing gear. A belt batcher for salt and a worm conveyer for delivering salt are operated by the same electric motor.

A two-layer stream of fish and water passes to an inclined belt conveyer and is delivered by it to a mixer-distributor located on the packing platform.

Technical Description of a Distributing Belt Conveyer

Type	Portable
Width of belt, in mm	500
Length between centres, in metres	10.0
Mounting angle	10 to 13°
Output in tons per hour	Not less than 30

The mixer-distributor distributes the mixture of fish and salt through the sloping troughs in two or four directions. On the troughs are installed oblique mixing guides (rails), arranged in staggered rows.

The fish that have been mixed with the salt are poured out into a barrel standing on a spring vibrator. The filled barrels are rolled off on roller conveyers installed at an angle of 2°. The factory-produced set of equipment of the line ends with the roller conveyers.

In order to ensure continuity and the multiple mechanization of all of the remaining processes, the line is supplemented with /285 MP7-A mechanical presses, fitted into the roller tracks, for sealing the barrels, and with barrel loaders for stowing the barrels in stacks; the fish must be kept until all of the salt placed in the barrels has dissolved. After this, the net weight of the salted fish in the barrels is determined by random checks.

The equipment of the line and its basic assembly can be dismantled and in this way shipped on trucks. The assembly and adjusting of the line takes about one day.

When the line is used for vat pickling, the fish are sent from the distributor-mixer to a belt conveyer with dumping blades, by which they are distributed among the pickling vats.

General Technical Description of the Line

Output of fish, in tons per hour	12 to 15
Rated power of equipment, in kw	14.8
Weight in kg	2,650

The lines that we have described were designed by the State Design Institute for the Fishing Industry (G.N. Likhota) in several subsequently improved modifications, the last of which was put into series production.

The lines in all three modifications have been very widely used in the Azov-Black Sea region for pickling anchovy and tiulka and in the Caspian area for sprat. The number of such lines operating on production for three years is in excess of 150, while the quantity of fish treated by them is in the hundreds of thousands of centners [100 kg in a centner], with a high-quality finished product.

2. A Prospective Scheme for the Multiple Hydraulic Mechanization of the High-Speed Barrel Pickling of Small Fish, Using Circulating Brine and without a Period of Settling for the Barrels (see Fig. 122)

The experiments of E.G. Vechkanov, A.A. Timofeev, N.T. Berezin and others have made it possible to create a basic system for a line for the high-speed pickling of small fish in barrels without a period of settling or adding [fish/salt]; this system uses circulating brine, vibrators and a mechanical assembly for pickling small fish.

The fish are unloaded from small ships with an RBU-100 fish-pumping unit, and pass through a trough water separator, a reticulate water separator-conveyer and a belt conveyer with belt scales fitted into it, i.e., they pass through quantitative receiving. Then, moving in a continuous stream, the fish pass through the pickling assembly, which consists of a vat with concentrated circulating brine entering at a pressure of 4 atmospheres from a diffuser. Thus, the brine and fish are mixed in a bath. The circulation system includes: a) a network of pipes /25
for discharging the spent, unsaturated brine that is removed from the bath at the end of the first quarter of its length and at the end of the bath itself; b) a sump for collecting this brine; c) a pump feeding the spent brine from the sump to a salt concentrator; d) the salt concentrator tank; e) a sump for collecting the saturated brine supplied by the filtering bin;

f) a second pump, delivering brine to the diffuser laid along the bottom of the pickling bath, and to the shower located above the bath. The shower abundantly sprays the surface of the bath with the fish floating in it, and also washes part of the reticulate conveyer unloading fish from the bath.

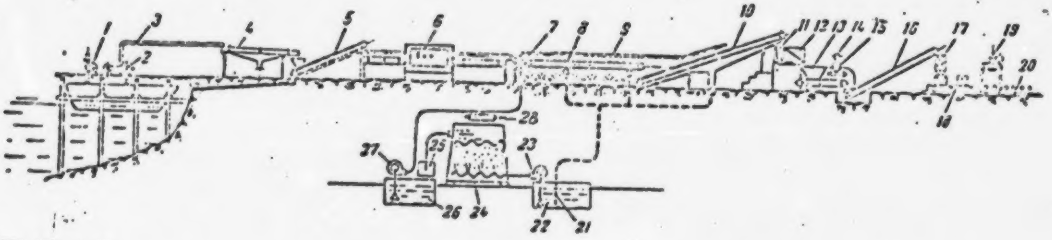


Figure 122 - A prospective scheme for the multiple hydraulic mechanization of the high-speed barrel pickling of small fish with the use of circulating brine and without periods of settling for the barrels:

1 - flooding pump; 2 - RBU-100 fish-pumping unit; 3 - fish delivery conduit; 4 - trough water separator; 5 - reticulate conveyer; 6 - belt conveyer with scales; 7 - pickling bath; 8 - scraper conveyer; 9 - shower; 10 - reticulate brine separator-conveyer for unloading; 11 - scales; 12 - scale bin; 13- feeder bin for fish; 14 - worm conveyer for feeding salt and spice; 15 - feeder bin for salt; 16 - issuing conveyer; 17 - distributing mixer-trough; 18 - vibrator; 19 - press; 20 - roller conveyer; 21 - conduit for thin brine; 22 - sump for thin brine; 23 - pump for pumping thin brine; 24 - salt concentrator; 25 - filtering bin; 26 - sump for concentrated brine; 27 - pump for pumping concentrated brine; 28 - conveyer for delivering salt to salt concentrator.

Salt is fed to the salt concentrator by a belt conveyer.

The place at which diluted brine is first recovered from the bath (at the end of the first quarter of the length of the bath) is determined by the fact that the most intensive decrease in the salinity of the brine takes place in this section. The pipe supplying brine to the shower is equipped with a valve that regulates the pressure in the shower pipes in order to prevent foaming of the brine as a result of the high speed at which it flows out of the openings in the shower pipe.

Over the pickling bath is mounted a chain scraper conveyer, which with its scrapers catches the fish, loads it into the brine, and, moving it through the bath, gives it an additional mixing. Intensive mixing helps to activate the salting process.

The bath is about 10 metres long; it is designed to hold /287 fish for 25 to 30 minutes. The speed of movement of the scraper conveyer is regulated by a cup-shaped, non-graduated [literally, unstepped] variator of the Svetozarov system.

At the end of the bath is installed an inclined reticulate conveyer that unloads the fish from the bath and separates them from the brine. At the beginning of the reticulate conveyer the fish are washed with brine from the shower in order to get rid of foam.

From the reticulate conveyer the fish move to the main assembly of the pickling line for small fish, described above.

Here they are strewn with salt and spices and poured into a barrel standing on a vibrator. After the fish have been settled in a barrel, it is sealed with a mechanical press using a stepped disc.

All further operations have already been described and are therefore not shown in the diagram.

It is assumed that the inclusion into the line of Vechkanov's pickling bath will permit the packing into a barrel of fish that have already to a considerable extent given off moisture and decreased in volume, as a result of which the shrinkage of the fish in the barrel after all of the salt has dissolved will be still less than was achieved during the pickling of fish on a vibrator in the experiments of I.N. Reznikov, N.T. Berezin and M.V. Timofeyuk.

The saltiness of the fish (tiulka) that are to be barrelled will amount to 8 to 10%. The barrelling of fish with such a salt content will permit a reduction in the dosage of salt in the barrel, which will in turn increase the overall output of the main assembly.

Technical Description of Line (approximate)

Output of fish in tons per hour.............	15 to 17
Rated power, in kw..........................	30

3. Multiple Mechanization of a Herring Plant where Fish are Pickled in Circulating Brine and Packed in Barrels (see Fig. 123)

On the wharf of a fish plant to which fish are delivered from trap nets in net bags tied to transport kungasy, is installed a hinged hoisting frame to which a net bag is fastened. After the net bag has been attached, the now freed transport kungas is dispatched to the fishing area for a new batch of fish. A complete RBU-200 fish-pumping unit with an intake valve (snore piece) on the end of its intake hose is installed on the wharf for unloading herring from the net bag.

For lifting the net bag, on the wharf there is a special device in the form of a long shaft with lugs; the del'* of the net bag is wound on the shaft from the /‾del's_7 edge. The shaft is rotated through a reducing gear.

Herring are pumped from the bag by a fish pump that transfers them to a hydraulic conveyer through which they are moved to pickling sheds with concrete vats equipped for pickling in circulating brine. /288

---

* Translator's note. See Translator's note, p 545 .

The fish are received by volume; a conversion is made to weight directly in the pickling vats, which are calibrated for this purpose. At many herring plants the fish are first transferred to receiving bins, where they are measured by volume and are then released into a hydraulic conveyer. The measuring of the quantity of fish in wooden measuring bins, however, is no more accurate than measuring in concrete vats with a regular geometric shape; the discharge of the fish from the measuring bins into the hydraulic conveyer leads to a loss of height in the conveying system and forces the introduction into the system of additional lifting facilities in the form of elevators, which is undesirable, since with such an arrangement the system and its maintenance become complicated and output is limited.

Before it enters the pickling shed, the hydraulic conveyer terminates in an inclined trough water separator with a grating of wooden strips or longitudinal metal rods. From the water separator the water is diverted to the sewer system, while the fish that have been separated from the water on the grating are transferred to another hydraulic conveyer that is fed with saturated brine from a brine station.

The fish are delivered along two branches of the brine conveyer to the pickling vats, where they pass through a mobile brine separator and fall into a vat. The brine that has been contaminated with scale, slime, and other impurities, and has been diluted with the water remaining on the fish, runs off into a trough situated between two rows of vats and is diverted into a sump. The brine is directed from the sump to a salt concentrator for purifying and strengthening (saturation with salt).

In the shed, the vats are arranged in four rows. Two rows represent a set. In each set there are 32 vats, and in each row, 16 vats. Above each set runs a branch of the brine conveyer, suspended from structural members of the shed roof. In the lower part of the trough of the brine separator are installed guide tongues made of wooden strips covered with strap iron, on which suspended brine separators roll on rollers, two on each branch.

An annular brine main 4" in diameter with welded-on four-pipe group collectors runs from the brine station around a set of vats. Outlets 1.5 to 2" in diameter, terminating at the centre of the vat bottom and shut off with valves or taps, branch out from the collectors into each vat.

All of the vats, with the exception of those on the end, have three apertures each that are closed with wooden insertion pieces. Two of the apertures lead to the neighbouring vats of the same row, while one leads out to a hydraulic trough conveyer installed in the concrete between the vats. Supporting brackets for attaching wooden beams with a cross section of 10 x 10 cm are set into the walls of the vats at the level of the lower edge of the apertures. The beams hold gratings under the surface of the brine. If the vat is not made of ferroconcrete and is not /289 reinforced, in its walls are fixed anchor bolts that reach to the bottom of the vat and are connected to check clamps. This is done in order that the vat will more uniformly absorb the stress developed by the gratings.

The gratings for each vat are usually made of two sections. A section consists of a wooden frame made of rods and sheathed with laths. Such gratings, however, are very heavy, and two men can shift them only with considerable difficulty. Therefore, before the brine is turned on, it is best to place freely lying boards of a length equal to that of the vat (2 metres) and with a cross section of 3 x 10 cm, on the fish. The clearances between the boards should be 5 to 6 cm. Across the boards should be laid two beams, whose ends must be brought in under the check clamps.

All wooden beams and boards should be fitted to the actual dimensions of each vat and should be branded with the number of the vat.

At the end of the shed is installed a common sump divided into two compartments: one for contaminated and unsaturated brine, and the other for pure saturated brine. In the compartment for unsaturated brine is mounted a detachable inclined reticulate conveyer-brine separator, which is removed when herring are being pickled in the vats and is set up when salted fish are being unloaded from them.

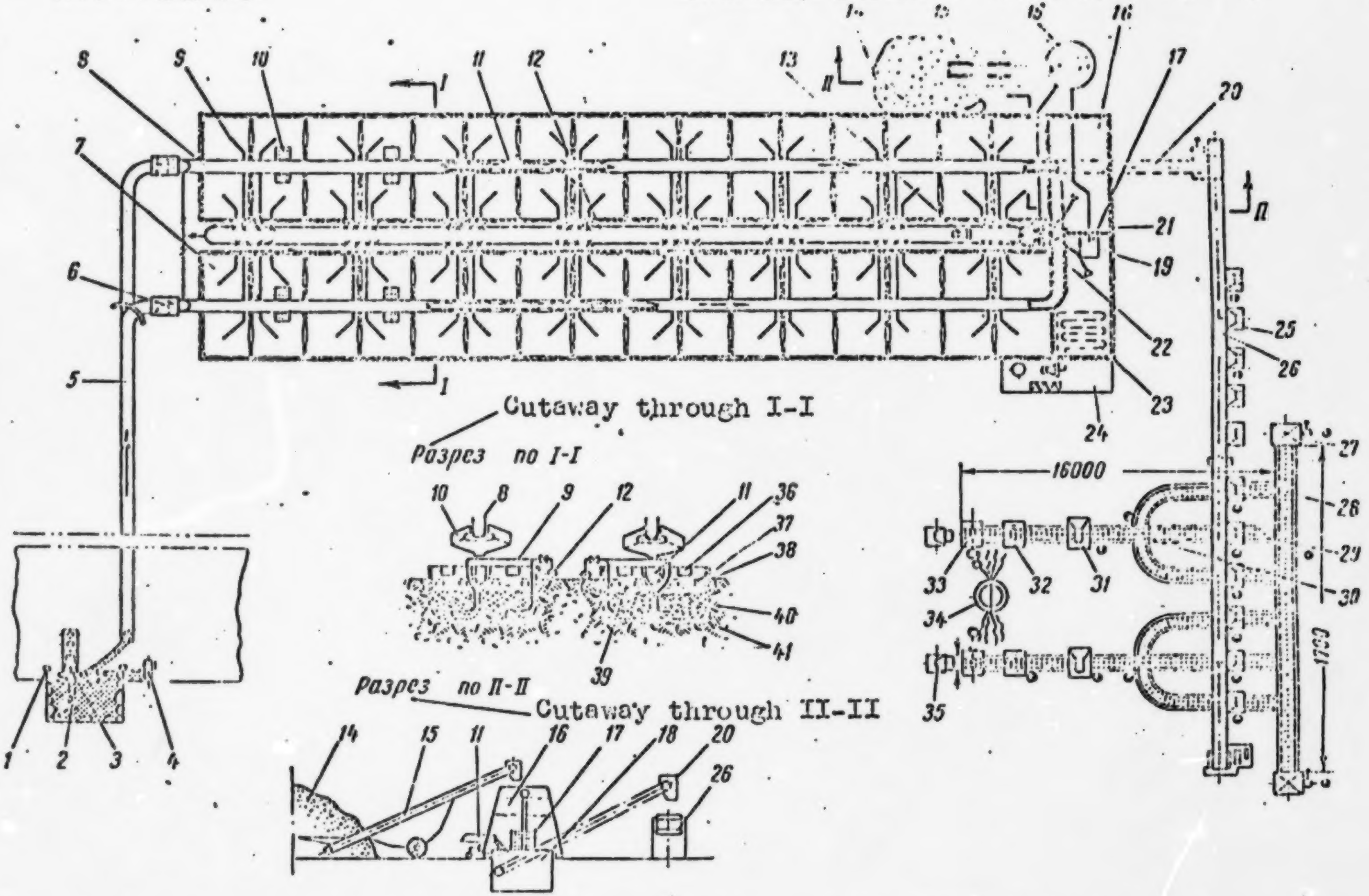

8
S
10
11
12
13
II
15
16
17
20
7
21
19
6
22
5
25
26
23
I
I
24
Cutaway through I-I
Разрез по I-I
16000
27
10
8
9
12
11
36
37
28
38
29
33
32
31
30
34
40
41
1700
39
35
Разрез по II-II
Cutaway through II-II
1
2
3
4
14
15
11
16
17
18
20
26

Figure 123 - A system for the multiple hydraulic mechanization of a herring plant in which pickling is performed in circulating brine, and the finished product is packed into barrels:

[For explanation of figures, please see next page.]

/Explanation of figures in Fig. 123:7

1 - cantilever frame; 2 - intake hose; 3 - RBU-200 fish-pumping unit; 4 - cylinder for lifting net bag; 5 - hydraulic conveyer; 6 - stationary water separators; 7 - concrete pickling vats; 8 - brine conveyer; 9 - brine distributing pipes; 10 - mobile suspended brine separators; 11 - concrete canting and unloading trough; 12 - brine main with four-pipe distributing collectors; 13 - mobile canting pump on trolley; 14 - salt dump; 15 - mobile belt conveyer; 16- salt concentrator; 17 - filtering bin; 18 - compartment of sump for unsaturated contaminated brine; 19 - compartment of sump for pure saturated brine; 20 - detachable inclined reticulate conveyer; 21 and 22 - pumps for circulating brine; 23 - cooling coil pipe; 24 - refrigeration unit; 25 - bins of sorting section on packing conveyer; 26 - packing conveyer; 27 - scales for weighing empty packing; 28 - roller conveyer tracks; 29 - working container /pocket/ of packing area above vibrator; 30 - rotatable spherical sections of roller conveyer tracks; 31 - hydraulic press for sealing barrels; 32 - scales for weighing barrels before they are flooded with brine; 33 - scales for weighing barrels after they have been flooded with brine; 34 - station for flooding barrels with brine; 35 - barrel loaders; 36 - apertures in the pickling vats; 37 - check clamp; 38 - pressure beam; 39 - pressure grating (board); 40 - layer of fish in vat; 41 - lower layer of brine in vat.

A pumping station that includes two centrifugal pumps is set up near the sump. One pump pumps brine from the unsaturated brine compartment through a salt concentrator, while the other delivers brine from the saturated brine compartment to the brine main. There are branch pipes from the pump for supplying the brine conveyer. The two pumps are connected with pipes. Valves on the conduits of the pumping station provide for the interchangeability of the pumps or their parallel operation; they also ensure the delivery of brine into the main, the brine conveyer and the salt concentrator. On the ends of the intake hoses of the brine station pumps are standard return valves, which may be transferred from one compartment of the sump to another as required. A block and tackle, with which the hoses are raised and lowered, is installed above the sump in order to take care of such operations /as transferring the standard return valves/.

Practice has shown that the use of multiple-blade pumps, as well as of pumps with more than 1,500 rpm, for pumping circulating brines, leads to increased foaming in the brine system and to frequent stoppages. We therefore consider that a 4NF or RB-100 pump, whose wheels have no more than 1,450 rpm, is the best type of pump for brine stations in sheds with a capacity of 5,000 to 7,000 centners /500,000 to 700,000 kg/.

Attached to the shed there is a salt concentrator with delivery from below for preparing fresh brine and for saturating unsaturated brine. It consists of a tank with a capacity of about /20

10 m^3 set up on blocks on the ground. On the bottom of the tank is laid a diffuser connected to a pumping station. In the upper part of the tank is installed an overflow pipe, which descends to the bottom of a filtering bin installed above the sump compartment for pure brine. The intake of the overflow pipe is enclosed with a coarse net. The salt concentrator tank is filled with salt to a depth of 1.5 metres. The salt is conveyed by a mobile belt conveyer from a dump located in the area of the salt concentrator. The salt concentrator itself is placed in the open air outside the shed and is equipped with a platform for maintenance.

When feeding herring are processed during the warm season, the brine is chilled to 2°. For this purpose a refrigerating unit with a 4AU-7 compressor is installed at the shed in a separate room. The pure brine sump is equipped with a coil pipe through which a coolant circulates.

For operations involving canting and unloading fish from vats, in order to deliver to the vats an increased quantity of brine, in the shed there is a C-203 mobile auxiliary pump installed with an electric motor on a trolley that rolls in the passageway between two sets of vats..

The following procedure has been adopted for filling the vats and canting the fish. When the pickling space is filled with raw fish, the end tubs in each row are left empty /of fish/, and they are prefilled with concentrated brine. In addition, there must be reserves of concentrated brine in the sump and in the middle vats. The vats in each row are filled with fish through one vat in such a way that while one suspended water separator is operating, the other is placed in readiness above an empty vat, which ensures the continuity of the stream of fish.

When the vat has been filled with fish to a level at which a pressure arrangement (boards or beams with their ends brought in under check clamps) can be freely placed on the fish, the volume of fish in the vat is measured according to a calibration [on the vat]. The pressure arrangement is then installed, and into the mass of fish down to the bottom of the vat is inserted a pipe 1" in diameter designed for relieving the vat of the pressure created by the pump. After this, the valve on the outlet of the brine conduit is opened, and brine enters the vat. When feeding herring are being pickled in a shed during the hot season of the year, a reduced quantity of fish (30 to 35% of the normal load) is fed into the vat, owing to which the pressure on the grating is decreased.

The brine is at first fed into the vat with the valve open to its greatest extent, but in such a way that there will not be a fountain of brine from the piezometric pipe; the opening of the valve is subsequently regulated so as to prevent increased pressure in the lower brine layer of the vat.

During canting, the fish are loaded from vat to vat in /291 brine. For this purpose a mobile pump is brought up to a vat containing brine, which it pumps into the vat where the fish are being canted. In the latter vat two apertures are closed with insertion pieces, and a third is opened which leads into the vat containing brine. The pressure arrangement is removed from the fish, the valve of the brine delivery pipe is fully opened, and the vat containing the fish is overfilled with brine which flows off through an open aperture into a vat serving as a brine reservoir; fish in the stream of brine that have risen to the surface also fall into this vat; two workers move the fish further along with rakers. At the end of the canting process, the brine and the fish change places. Then in the last vat a weight is placed on the fish and here normal circulation is established; the fish in the next vat are subsequently canted.

The salted fish are unloaded in the same way into a concrete trough and through it are delivered to the reticulate conveyer of a brine separator, from which they fall onto a packing conveyer.

The packing conveyer has a section for sorting the herring that have been unloaded from the vats and are proceeding to packing. In this section herring with injuries or unsatisfactory external appearance are removed by hand. The herring then fall onto the packing section, under which is a system of roller conveyers going across the axis of the conveyer. Washed and weighed barrels are brought up along roller conveyers under the packing positions of the conveyer, which are equipped with vibrators.

The herring may be poured with a blade from the belt of the conveyer into a detachable packing container [pocket], from which they are evenly poured by a woman packer into a barrel standing on an operating vibrator. The packer always smooths out the herring in the barrel by hand as they are poured in. For a centner-and-a-half [150 kg] barrel the pouring lasts 1.5 minutes; the barrel is then kept for an additional 1.5 minutes on the vibrator and rolls down a roller conveyer for sealing. This method yields a considerable increase in packing output (8 to 10 times), but its introduction is hindered by the fact that there is a slight deterioration in the appearance of herring that are not packed in rows. In actual practice, herring are packed in barrels in rows without vibration. Sealing is carried out by a hydraulic press using a sealing plate.

The barrel being sealed is weighed on scales installed in the track of the roller conveyer, is flooded under pressure with brine at a brine-flooding station, is weighed a second time and is stenciled. The stencil indicates the gross weight of the barrel, the weight of the barrel only [without the contents], the net weight of the contents of the barrel with the brine and the weight of the salted herring without the brine.

The [production] line that we have described can also be used partly for packing lightly salted and medium salted herring into boxes. For this purpose the packing container [pocket] is replaced by a bin, where the woman packer keeps a working stock of herring, and at the working area a packing table is set up on which herring are packed in boxes by hand. /292

The packed boxes are sent along a roller conveyer track for stacking and holding, after which they are removed beyond the line.

The system that we have described is in use at herring plants in the Far East.

Technical Description of Line

Output of first cycle for receiving raw herring for processing	Unlimited
Output of salted finished product, in tons per hour......................	12 to 15
Rated power (without fish pumping unit) in kw...............................	68

4. Prospective System for a Consolidated Herring Pickling Plant with Hydraulic Mechanization of Receiving and Processing

(see Fig. 124)

(designed by the Sakhalin Division of the State Design Institute for the Fishing Industry, I.P. Kostromin)

The consolidated pickling plant for herring consists of a complex of 10 pickling sections, each with a one-time pickling capacity of 7,800 centners [780,000 kg], assembled into two groups of 5 sections each, with a capacity of 28,000 centners [2,800,000 kg], around two mechanized packing sections.

The fish are fed into each group of sections by RB-250 fish pumps through a system of hydraulic trough conveyers. The fish pumps are located on two fish receiving wharves.

Between the two groups of sections there is a central salt-concentrating station (described in Chapter X) with a salt dump.

The internal mechanization of the pickling sections is effected on the principle of the standard hydraulic mechanization of the pickling of herring in vats with circulating brine.

The centralized storage of the salt and preparation of the brine, the organization of the packing of the fish in mechanized group packing sections, and the overall layout of the pickling sections on a plane greatly simplify all of the transport operations and reduce the length of the traffic to a minimum.

5. A Prospective System for the Multiple Hydraulic Mechanization of the Pickling of Pink Salmon (see fig. 125)

There has hitherto been little development of the multiple mechanization of salmon plants. The reason for this has been the lack of proven methods and machinery for mechanizing /295 the pickling, unloading from vats and packing of salmon.. The lack of multiple mechanization has appreciably affected the work of salmon plants.

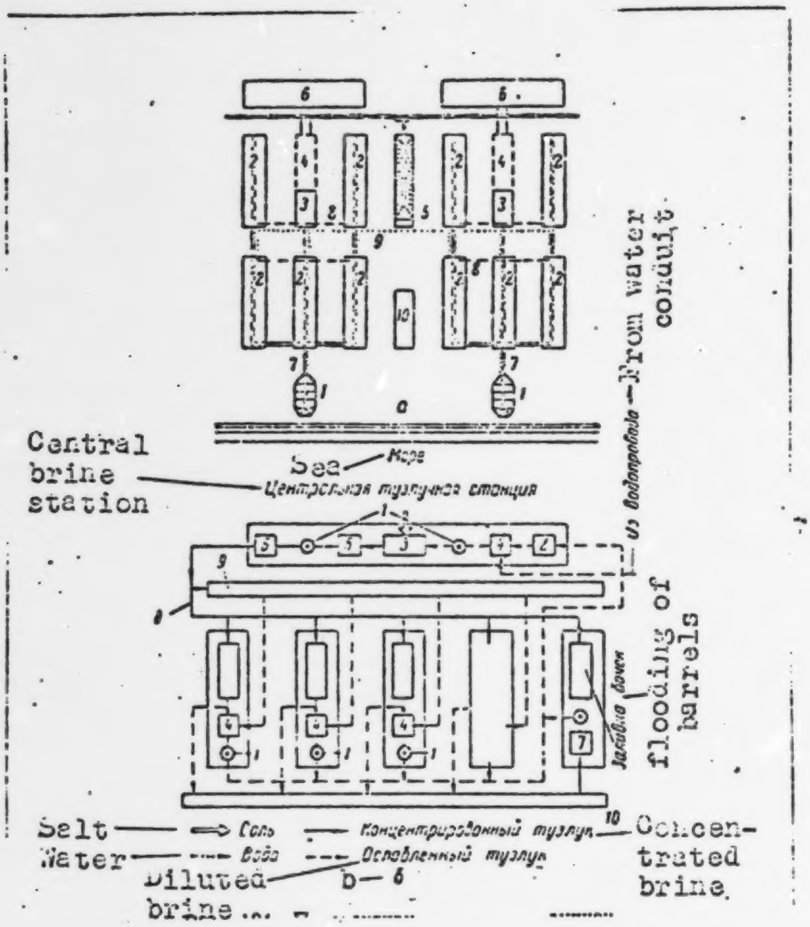

6
6
2
4
3
5
9
8
10
7
1
a
Central brine station
Sea — Море
Центральная тузлучная станция
из водопровода — From water conduit
flooding of barrels
Заливка бочек
Salt — Соль
Water — Вода
Концентрированный тузлук — Concentrated brine
Diluted brine — Ослабленный тузлук
b — б

Figure 124 - Prospective system for a consolidated herring pickling plant with hydraulic mechanization of receiving and processing:

a - Layout 1 - fish receiving wharf; 2 - brine pickling section; 3 - packing section; 4 - shed (auxiliary area of packing section); 5 - salt storage and central brine station; 6 - barrel and fish storage; 7 - brine conveyer on a gantry; 8 - ground brine conveyer; 9 - brine conduit; 10 - service and utility rooms.

b - Line diagram of brine system: 1 - centrifugal pump; 2 - filters; 3 - platform for salt; 4-sump for weak brine; 5 - sump for concentrated brine; 6 - supply reservoir; 7 - loading sump of packing section; 8 - brine main in pickling section; 9 - brine conveyer on gantry; 10 - ground brine conveyer.

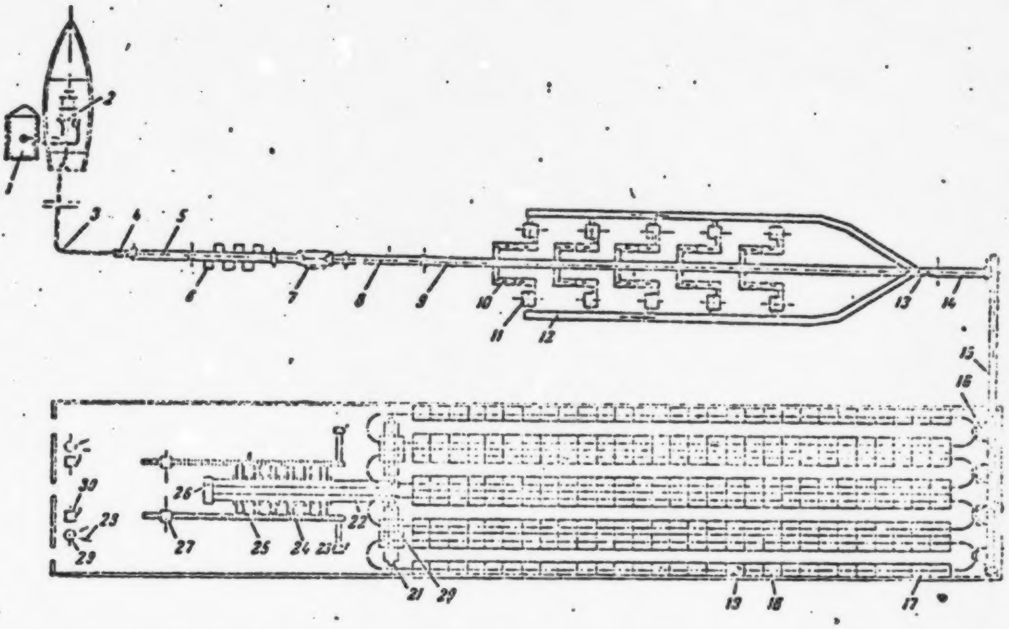


Figure 125 - Prospective system of multiple hydraulic mechanization of pickling pink salmon:

1 - net bag with fish; 2 - fish-pumping unit on kungas; 3 - tubular hydraulic conveyer; 4 - water separator; 5 - sorting conveyer; 6 - bins for sorting (by species) other fish taken along with those of commercial value; 7 - belt conveyer scales; 8 - inclined belt conveyer; 9 - belt conveyer [and] filleting conveyer; 10 - Usov machines; 11 - Kapustyanskii head-cutting machines; 12 - brine conveyer for filleted fish; 13 - brine separator; 14 - inclined conveyer; 15 - transmitting [sic] belt conveyer-distributor; 16 - bin for packing fish in bulk into containers; 17 - pickling vats; 18 - suspended track; 19 - telphers; 20 - feeding bins of packing conveyer; 21 - feed carriers of packing conveyer; 22 - belt conveyers; 23 - scales for weighing packaging [e.g., barrels]; 24 - roller conveyer tracks; 25 - packing areas with vibrators; 26 - terminal bin; 27 - mechanical presses; 28 - hoses for flooding barrels with brine; 29 - supply tank with brine; 30 - centesimal scales for finished product.

We present a prospective system for the multiple hydraulic mechanization of a pickling plant for salmon with the application of pickling in circulating brine in containers.

The fish are unloaded from a net bag with an RB-250 fish pump installed on a kungas and are conveyed through a fish conduit made of hose to the shore. The remainder of the system specifies the immediate continuous treatment of all incoming fish, which at the end of the first cycle are submerged in cold circulating brine in pickling vats; after the fish pump, therefore, there are no accumulators in the form of bins, wharves or platforms in the system.

After [passing through] the fish pump, the fish enter a trough water separator and proceed further to a sorting conveyer, where [useless or rare] fish that have been taken along with those of commercial value and have been thrown off into hopper trolleys (for sorting by species) mounted on centesimal scales on both sides of the conveyer, are removed from the main mass of the fish. The non-commercial fish, after they have been sorted, are weighed and sent in hopper trolleys for further processing.

The main mass of the fish - pink salmon - passes in a stream through the belt conveyer scales, is weighed and enters the filleting section, where it is filleted on Usov machines.

Pink salmon are now filleted for pickling without decapitation. It is desirable to inspect salmon processing in which the head is removed, since the head and the gills decay the most rapidly. Moreover, the absence of a head can facilitate the penetration of brine within the abdominal cavity.

Since an Usov machine does not sever the heads from fish, in this system to each Usov machine there is attached a head-cutting Kapustyanskii machine. The heads are sent for pickling separately and can later be sold as a fodder or food product.

The decapitated or undecapitated eviscerated pink salmon enter the brine conveyer, by which they are delivered to a reticulate conveyer-water separator, which separates the fish from the brine and conveys them to a belt conveyer. The latter delivers the fish to the pickling shed.

The vats of the pickling shed are equipped for pickling in chilled circulating brine. For this purpose the shed is equipped with a salt concentrator, a cold producer and a brine distributing network (not shown on the diagram).

The pickling is carried out in containers; for operations with the latter, suspended monorail tracks with telphers or hand trolleys with block and tackle are installed in the shed. The containers are vessels of a light latticed construction; they are made of vinyl plastic or plasticized wood and are equipped at the top with lids on hinges.

The fish are loaded into the containers in bulk from the conveyer belt, after which the container lids are closed and the containers are conveyed along the monorail to the vat and lowered /296 into it; in the process, the fish are loaded into cold, circulating, saturated brine. After intervals of time which are determined experimentally, the fish are canted. In this case, canting involves lifting the container with the fish from the vat and pouring the fish from one container into another, which is then again immersed in chilled, concentrated circulating brine. During such canting, the fish will be freed of diluted brine and will change their positions, as a result of which the fresh brine will obtain access to all specimens and inside them. The decapitation of the fish and the chilling of the brine will help to keep the fish from spoiling and will promote the obtaining of a high-quality product.

The salted fish are removed from the vats in the containers and are delivered along a monorail for packing. The packaging of the fish is carried out on conveyers, since there have so far been no machines for performing this operation, and the vibration method of packing salmon by pouring [them into barrels] on a vibrator has not yet been tested.

Further packing is carried out on roller conveyer tracks, on which are mounted presses for forcing out and sealing the barrels, nail-driving and wire-binding machines for packing in boxes, and scales for weighing before stenciling.

6. The Multiple Mechanization of the Catching and Processing of Sprat on Board Ship

(see Fig. 126)

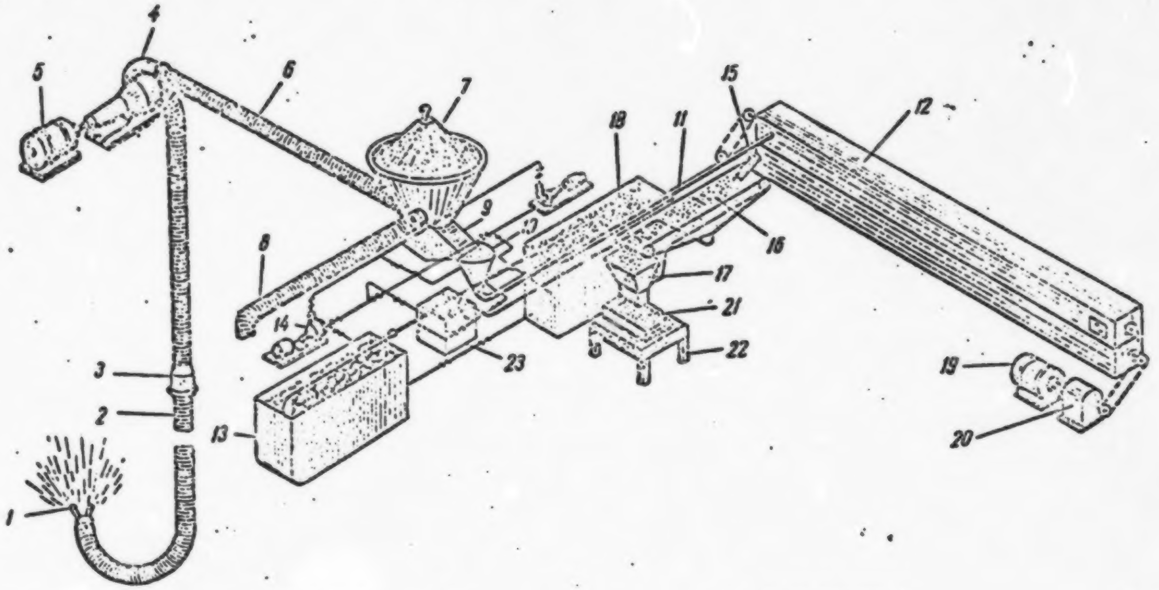


Figure 126 - A system of multiple mechanization of the catching and processing of sprat on board ship:.

1 - catching device; 2 - hose; 3 - return valve; 4 - RB-150 fish pump; 5 - electric motor; 6 - hose; 7 - water separator; 8 - hose; 9 - trough; 10 - bin; 11 - hose; 12 - cooling device; 13 - cold producer; 14 - pump; 15 - hose; 16 - conveyer; 17 - receiving and packaging device; 18 - sprinkler; 19 - electric motor; 20 - reducing gear; 21 - box; 22 - table; 23 - salt concentrator.

As a result of the successful application of underwater electric illumination and a fish pump for catching sprat, removals of /this/ fish have been considerably increased and accelerated. The problem of mechanizing the processes whereby fish are treated on the same ship from which they are caught, has therefore arisen with all urgency.

Officials of the Caspian Porcessing Division of VNIRO, headed by N. S. Volkova, have successfully solved this problem by creating a mechanized line for processing sprat in refrigerated form. All of the equipment has been placed on the deck and in the hold of the refrigerator ship, as a result of which the multiple mechanization of the catching and processing of sprat has been developed.

The underwater electric illumination and fish-pumping units mounted on the ship have been described in Chapter IX; here, therefore, we shall dwell on the subsequent equipment of the mechanized line.

The branch delivery pipe of the fish pump was connected to a cascade water separator installed on the ship's deck. The water that was separated from the fish ran overboard through a hose, and the sprat entered the receiving bin through a trough.

The sprat were washed from the bin with cold brine and were conveyed through a hose to a cooling device, which, like all the other equipment, was placed in the hold. Cold brine, /298 with a temperature of-3°, was pumped from the cold producer with a centrifugal pump.

The cooling device for the sprat consisted of two metal troughs with a rectangular cross section placed one over the other.. Within the trough were shafts that were rotated through a reducing gear by an electric motor and that had wooden blades mounted on them for stirring the sprat. After passing through the cooling device, the sprat moved through the hose to a conveyer-water separator, whose belt had several openings for removing the brine. The brine collected in a bottom pan and was piped to the cold producer through a sprinkler. After being cooled, the brine was again used for washing the sprat from the receiving bin.

From the conveyer-water separator the sprat passed into a receiving and packing bin with an opening bottom, under which was set up a table for packing the sprat into boxes. This simple multiple mechanization ensured the output of a high-quality refrigerated fish product directly on board ship.

Bibliography

Berezin, N. T.
Promyslovaya obrabotka ryby,
Pishchepromizdat,
(The commercial processing of fish.
State Scientific and Technical
Publishing House for the Food
Industry, 1951)

Gusinskii, D. A., and
Sukhovii, A. S.
Mekhanizatsiya trudoemkikh rabot v
rybnoi promyshlennosti Ukrainskoi SSR,
Gostekhizdat Ukrainy.
(The mechanization of laborious operations in the fishing industry of the
Ukrainian Soviet Socialist Republic.
State Publishing House for Technical
and Theoretical Literature of the
Ukraine, 1951)

VNIRO "Trudy".
Pishchepromizdat.
(Proceedings of the All-Union Scientific
Research Institute of Ocean Fisheries
and Oceanography, vols XXII and XXVII,
State Scientific and Technical Publishing House for the Food Industry)

Dormenko, V. V.	Beregovye i sudovye rybopromyslovye ustanovki i mekhanizmy, Pishchepromizdat. (Ship and shore commercial fisheries installations and machinery. State Scientific and Technical Publishing House for the Food Industry, 1953)
Es'man, I. G.	Nasosy, Gostoptekhizdat. (Pumps. State Scientific and Technical Publishing House for Oil and Fuel Literature, 1954)
Evilevich, A. Z.	Udalenie kanalizatsionnykh osadkov po napornym trubam, Gosstroiizdat. (The disposal of sewage sediments through stand pipes. State Publishing House for Literature on Construction, Architecture and Building Materials, 1939)
Levanidov, I. P.	Gidravlicheskii posol sakhalinskoi sel'di, Sakhpravda. (The hydraulic pickling of Sakhalin herring. Sakhalin Pravda, 1956)
Nikonorov, I. V.	Mekhanizatsiya vygruzki ryby. (Mechanizing the unloading of fish. Astrakhan, 1950)

Nikonorov, I. V.	Lov kil'ki pri promoshchi elektrosveta i rybonasosa, Pishchepromizdat. (Catching sprat using electric light and a fish pump. State Scientific and Technical Publishing House for the Food Industry, 1955)
	"Rybnoe khozyaistvo" - zhurnal. (The magazine _Fishing Industry_, 1950-1956)
Sviderskii, P.A.	Nasosy dlya rybnoi i konservnoi promyshlennosti, Pishchepromizdat. (Pumps for the fishing and canning industries. State Scientific and Technical Publishing House for the Food Industry, 1943)
Terent'ev, A. V., Miller, B. N., and Chernigin, N. F.	Gidravlichiskaya mekhanizatsiya v rybnoi promyshlennosti, Pishchepromizdat. (Hydraulic mechanization in the fishing industry. State Scientific and Technical Publishing House for the Food Industry, 1950)
Terent'ev, A. V.	Kompleksnaya mekhanizatsiya rybozavodov, Pishchepromizdat. (The multiple mechanization of fish plants. State Scientific and Technical Publishing House for the Food Industry, 1953)

Uginchus, A. S.	Gidravlika i gidravlicheskie mashiny, Gosenergoizdat. (Hydraulics and hydraulic machines. State Scientific and Technical Publishing House for Power Engineering, 1953)
Chernigin, N. F.	Mekhanizatsiya truda v rybnoi promyshlennosti Dal'nego Vostoka, Dal'giz. (The mechanization of labour in the fishing industry of the Far East. Far Eastern State Publishing House, 1950)
Yufin, A. P.	Napornyi gidrotransport. Gosenergoizdat. (Hydraulic transport under pressure. State Scientific and Technical Publishing House for Power Engineering, 1950)
